Weeds

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Weeds

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Weeds

JOURNAL OF THE WEED SOCIETY OF AMERICA

VOLUME IV JULY 1956 NUMBER 3

Leaching and Decomposition of 2,2–Dichloropropionic Acid in Several Iowa Soils[1]

J. T. HOLSTUN, JR. and W. E. LOOMIS[2]

THESE studies were an attempt to evaluate some of the factors affecting the detoxification of 2,2–dichloropropionic acid in soils. Residual toxicity is a factor that must be evaluated before effective use can be made of any herbicide. Stability is preferred for purposes of soil sterilization; rapid disappearance of the herbicide may be essential in preplanting treatments; and in foliar applications, rapid disappearance of the material that reaches the soil may be important. Detoxification is usually considered to be the result of one or more of the several processes, decomposition, leaching, adsorption, and volatilization.

The herbicide 2,2–dichloropropionic acid (dalapon) has been developed so recently that relatively little information is available on the behavior of the chemical, although a large amount of work has been done on the related trichloroacetic acid (TCA), and on other less similar herbicides.

Insofar as the properties of any herbicides are concerned, solubility in water is a major factor in leachability. Water-soluble TCA appears to be extremely mobile in several soil types (13, 16), and appreciable leaching of water-soluble formulations of derivatives of 4,6–dinitro ortho secondary butylphenol by 2 surface-inches of water has been reported (6). Several investigators (11, 14, 18) have reported relative immobility with less soluble herbicides such as isopropyl N–(3–chlorophenyl) carbamate, and 3–(*p*–chlorophenyl)–1,1–dimethylurea. In a review paper, however, Aldrich (2) points out that differential solubility in water is not the only explanation for differences in leaching of various herbicides. Several investigators have reported inhibition of the movement of herbicides in soils by adsorption by soil colloids or organic matter.

For most herbicides, detoxification by decomposition appears to be primarily a function of microbiological activity (2, 3, 5, 9, 10, 11, 15). Rai and Hamner (17) found only slight toxicity to wheat

[1]Journal paper No. J-2811 of the Iowa Agri. Exp. Sta., Ames, Iowa; project 944.

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seedlings in sandy soil 42 days after treating with 15 to 60 lb of TCA per acre. Moderate injury to wheat was observed on a clay loam soil, while on a muck soil marked toxicity persisted for at least 108 days. Ogle and Warren (16), however, reported the slowest detoxification of TCA in a sandy soil and the fastest in muck. Loustalot (13) found that the persistence of toxicity was longer under dry soil conditions, in heavier soils, at lower temperatures, and when the highest rates were used. The effect of such factors as soil pH, and additions of lime and manure on the decomposition rate of 2,4–D in soils may vary with different soil types or conditions (1, 5, 8, 12). It is probable that this is also true for other herbicides.

Southwick (19) reported that, under greenhouse conditions with heavily watered soil, the toxicity of 40 lb/A of dalapon persisted for 8 to 12 weeks. Brown (4) reported that 40 lb/A of dalapon applied in June was still toxic to alfalfa and sweet clover one year later under field conditions. In these experiments, both leaching and decomposition were factors. Appreciable loss of dalapon from soils by volatilization does not appear likely.

MATERIALS AND METHODS

The sodium salt of 2,2–dichloropropionic acid (dalapon) was used in all experiments. Except as will be noted, it was prepared by neutralization of reagent grade (97 per cent) 2,2–dichloropropionic acid with sodium hydroxide. The quantities of dalapon are presented on the basis of the acid equivalent.

The soils used in the leaching and decomposition experiments were collected in the field, screened and air-dried. Some properties of these soils are presented in Table 1. The details concerning soil modification are presented with the results of individual experiments.

Table 1. Properties of soils and modifiers used in decomposition and leaching studies.

Soil type or modifier	Soil type abbreviation	pH	Field capacity	Loss on ignition pct.	Organic matter pct.
Fayette med. silt loam (field limed)	F6.5	6.5	13.5	3.7	—
Fayette med. silt loam	F5.1	5.1	14.8	—	1.44
Webster silty clay loam	Web.	7.7	24.8	—	7.09
Luton silty clay	Lut.	6.8	32.5	—	—
Ida-Monona silt loam	I-M.	7.8	14.9	—	1.79
Soil-manure lot 1	M_1	—	—	25.10	—
Soil-manure lot 2	M_2	—	—	—	16.43
Peat	P	—	—	42.00	—
Creek bank sand (fine and white)	S	—	—	(Assumed to be low)	

Soybeans (Hawkeye) were used as test plants in the leaching studies, and millet (Large Yellow) was used in the bioassays for the decomposition experiments.

In the leaching studies, soil columns about 7 inches high by 2.6 inches in diameter were formed in glass tubes. These columns were thoroughly wet and allowed to drain overnight. Dalapon, equivalent to 24 lb/A on an area basis, was added to the surface of the soil

columns in water solution equivalent to 0.5 surface-inches. Then two additional 0.5 inch applications of water were used, each being added when the preceding portion had disappeared into the soil column. After an appropriate interval of drainage, the top 6 inches of each column was sectioned into successive 1-inch layers. Soybeans were grown in the soil of these layers for 10 to 14 days after emergence. The green weights of growth above the cotyledonary node were used as the response indicator. The development of the test plants in the treated soil was compared with that made in similarly handled soils of known dalapon concentration.

In the decomposition studies, dalapon was added to air-dry soil at the rate of 120 ppm on an oven-dry basis. It was applied in the necessary volume of water to adjust the moisture content of the soil to a specific level and thoroughly mixed with the soil sample. Except for studies involving sterilized soil, the herbicide-soil mixtures were stored in quart jars. For each sample treated with dalapon, there was an untreated sample that was handled in a similar manner. Four replications of each treatment were used. Aeration for the soil was provided by using loose lids for the jars or by opening the jars and forcing in air at weekly or shorter intervals.

The dalapon remaining in each treated soil sample was estimated at various intervals by a bioassay technique. The equivalent of 20 grams of oven-dry soil from each jar was placed in a petri dish, and planted with 20 millet seeds. The soil moisture content was adjusted to the predetermined percentage required for optimum growth of the millet. The elongation of the seedling shoots was determined after growth for 96 hours in an incubator at 27° C. The average length of the longest 10 plants in each dish was converted to a percentage of the appropriate control. A standard curve of the response of millet to known quantities of dalapon was prepared for each soil type and modification studied. The dalapon in the unknown samples was estimated by reference to these standard curves.

EXPERIMENTAL RESULTS

Leaching of Dalapon in Soils. In preliminary experiments it was found that 24 lb/A of dalapon was completely leached from the surface inch of Fayette medium silt loam (F6.5), Fayette medium silt loam (F5.1), and Webster silty clay loam by as little as 2 inches of water.

Following these preliminary experiments, an experiment was conducted to evaluate the effect on leaching of additions of fine sand or organic matter to three soil types. The soil types, Fayette medium silt loam (F5.1), Webster silty clay loam, and Ida-Monona silt loam, were modified by the addition of 10 and 20 per cent sand, or 4 and 8 percent organic matter in manure (M_2). The leaching characteristics were obtained for each original soil, and for each modification. The results, presented in Table 2, indicate that there was little adsorption of dalapon by any of the three soil types. After leaching with 1.5 inches of water, the highest concentrations of dalapon were

Table 2. Percentage reduction in growth of soybeans 10 to 14 days after planting in successive one-inch layers of soil that had been treated with 24 lb/A of dalapon and then leached with 1.5 inches of water.

Soil type[1]	Modifiers	Depth of soil layer (inches)					
		0–1	1–2	2–3	3–4	4–5	5–6
F5.1	none	0	0	38	54	36	27
F5.1	10 per cent sand	20	0	30	77	60	29
F5.1	20 per cent sand	2	20	23	46	48	34
F5.1	4 per cent org. matter	12	15	56	59	38	18
F5.1	8 per cent org. matter	10	53	86	72	50	16
Web.	none	18	18	53	52	21	8
Web.	10 per cent sand	0	0	5	38	38	36
Web.	20 per cent sand	0	32	32	58	22	34
Web.	4 per cent org. matter	6	35	70	70	55	31
Web.	8 per cent org. matter	37	48	68	49	50	50
I-M.	none	0	0	58	58	31	30
I-M.	10 per cent sand	0	0	16	50	34	3
I-M.	20 per cent sand	22	4	42	74	31	34
I-M.	4 per cent org. matter	0	36	72	66	31	11
I-M.	8 per cent org. matter	18	29	44	40	25	14

[1]F5.1—unlimed Fayette med. silt loam.
Web.—Webster silty clay loam.
I-M.—Ida-Monona silt loam.

2 to 4 inches deep in all three soil types. The addition of sand increased the downward movement of dalapon, but the effect was slight. The addition of organic matter did not appear to affect the location of the maximum dalapon concentration, but did increase the quantity retained in the upper 2 inches of the soil. Reduced growth of soybeans or formative effects were noted on the plants grown in the four lower sections of the columns of all soil types and modifications, indicating appreciable quantities of herbicide in these layers.

Supplementary tests made with soybeans grown in all of the soils and modifications containing known quantities of dalapon, indicated that rates equivalent to 4 to 8 lb per acre-inch reduced growth appreciably and that rates as low as 1 lb/A were detectable by formative effects.

These responses to known rates were variable to the extent that it appeared advisable to restrict quantitative assessment of the dalapon in the unknowns to relative values. The highly contaminated sections were assumed to contain one-third or more of the original application. Apparent growth reductions up to 20 or 25 per cent were considered to be the result of inherent variation unless distinct formative effects were also present.

Decomposition of Dalapon in Soils. The quantity of dalapon remaining in certain soils with various modifications under various conditions was estimated after specified intervals by use of the millet-seedling bioassay. Small differences between treatments were not detectable with this method, but trends and large differences were readily established. The largest source of variation was that due to treatments in a transition stage from slow to rapid decomposition. No attempt was made to define differences between treatments if all of the average estimates were over 85 ppm, and if no definite

trend had been established. Likewise, no attempt was made to define differences between treatments on any given date of sampling in which the average estimates were all below 15 ppm.

Soil temperature was shown to affect the decomposition of dalapon in one soil as shown in Figure 1. In this experiment 120 ppm of dalapon were added to Fayette medium silt loam (F6.5) in solution with the necessary volume of water to obtain a moisture level equal to the field capacity. After adding the dalapon the soil was stored in temperature control cabinets at the specified temperature levels. Bioassays were conducted 1 and 2 weeks after adding the dalapon.

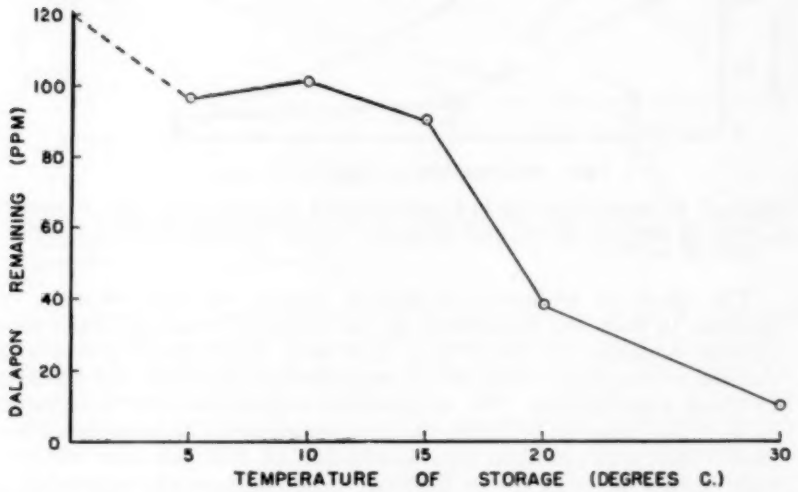

Figure 1. Dalapon remaining in Fayette medium silt loam (F6.5) after treatment with 120 ppm of dalapon and storage for two weeks at five temperatures with the soil moisture at field capacity.

Little or no decomposition of dalapon occurred in two weeks when the soil temperature was less than 15° C. With a soil temperature of 30° C, decomposition was essentially complete in two weeks.

The relation of soil moisture to decomposition of dalapon was indicated in a second experiment conducted in a similar manner. Bioassays were run 2, 8, and 16 weeks after adding dalapon to the F6.5 soil. Moisture levels of 0.25, 0.50, 0.75, or 1.0 times the field capacity were used. As shown in Figure 2, decomposition was slower but eventually complete when the soil moisture level was 0.5 of the field capacity, or near the permanent wilting percentage. When the soil moisture was only 0.25 times the field percentage, or approximately the hygroscopic percentage, significant decomposition did not occur in 16 weeks. Decomposition was faster in soil at the field capacity than in soil at 0.75 times the field capacity, but was essentially complete at both of these levels after 8 weeks.

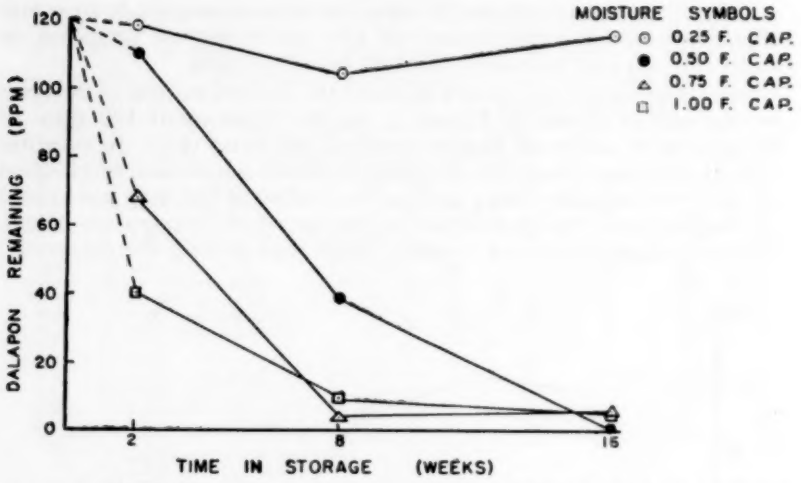

Figure 2. Dalapon remaining in Fayette medium silt loam (F6.5) after treatment with 120 ppm of dalapon and storage at four levels of soil moisture at a temperature of 27°C.

The effect of additions of organic matter on detoxification of dalapon in soils was dependent on the original reactions of the soil. Fayette medium silt loam that had been field limed (F6.5) and Fayette medium silt loam (F5.1) were used as the basic soil variates in these experiments. The original decomposition rate was rapid in F6.5 and slow in F5.1. In the first experiment, Fayette med. silt loam (F6.5) was modified by the addition of 8.78 per cent combustible matter in peat (P) or 7.84 per cent combustible matter in a manure-soil mixture (M_1). Soil moisture levels for the unmodified soil were 17.4 and 23.8 per cent; for the plus-peat modification the levels were 25.7 and 34.3 per cent; and 26.2 and 35.0 per cent for the plus-manure modification. After treatment with 120 ppm of dalapon at room temperature, the jars of soil were stored at either 0.5° or 25.0° C. Bioassays were made 1, 4, and 16 weeks after addition of the dalapon.

No significant differences were attributed to differences in the moisture levels, which were both above the field capacity, and values for the two moisture levels were averaged as indicated in Figure 3. Little decomposition took place in any soil variate at the lower temperature in 16 weeks. At 25.0° C, decomposition was most rapid in the unmodified soil and was practically complete in 4 weeks. Decomposition was slowed by the addition of organic matter, particularly by the biologically more active manure. The inhibition was temporary, however, and decomposition was essentially complete in all soil variates in 16 weeks at the higher temperature.

In the second experiment, unlimed Fayette med. silt loam (F5.1) was modified by the addition of $Ca(OH)_2$ equivalent to 4 tons of $CaCO_3$ per acre, or by addition of 10 per cent combustible matter

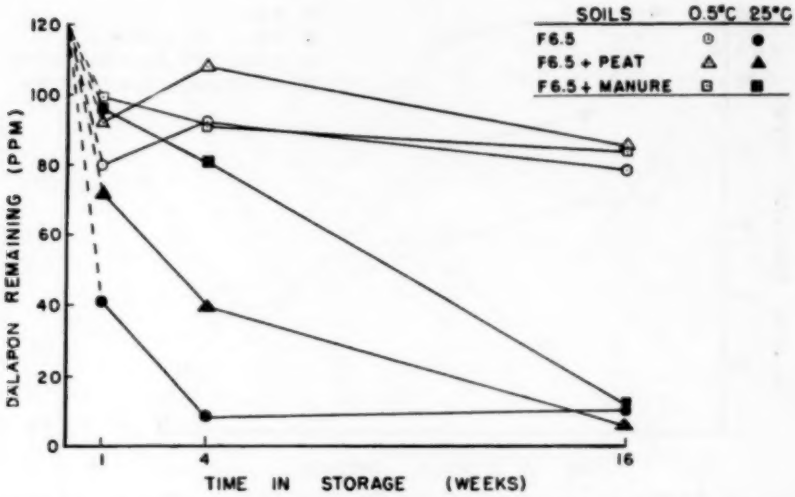

Figure 3. Dalapon remaining in Fayette medium silt loam (F6.5) and two modifications after treatment with 120 ppm of dalapon and storage at two temperatures (moisture levels averaged).

in a manure-soil mixture (M_1), or by the addition of both lime and manure. The original soil and all modifications were then stored in loosely covered cans, saturated with water, and incubated for over 3 months at room temperature. This preliminary treatment was intended to effect equilibrium of chemical and biological factors in the soil samples. At the end of this period the soils were air-dried, screened and stored for about 7 weeks prior to beginning the experiment. Several days prior to addition of the dalapon the pH values were determined and the soils were chilled to 6° C. The pH value was 5.1 for the unmodified soil. The lime had increased the pH to 6.9, manure increased it to 7.3 and the addition of both lime and manure raised the pH of the soil to 7.5. Dalapon at 120 ppm and water necessary to bring all soils to a moisture content 1.5 times the field capacity were added in a cold room at 6° C. After mixing with the herbicide and water, the soil lots were placed in temperature control chambers at either 17° or 30° C. Bioassays were conducted 1, 2, 4, and 8 weeks after adding the herbicide.

All of the factors, pH, temperature, and organic matter, affected the rate of decomposition. At 17° C little or no decomposition of the herbicide occurred in the soil or any of its modifications in 8 weeks. The results at 30° C are shown in Figure 4. The addition of lime to this acid soil increased the rate of decomposition, but had no significant effect where organic matter had been added. It should be noted that the addition of the organic matter mixture raised the pH more than the addition of lime. The addition of organic matter increased the initial rate of decomposition as compared to the

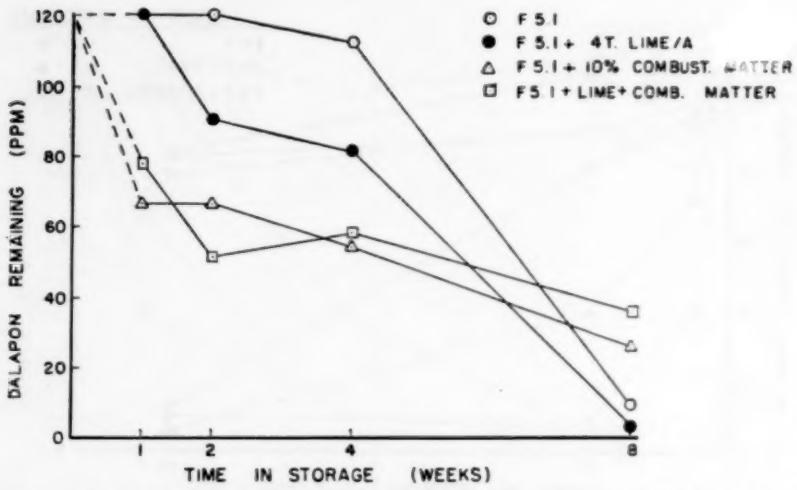

Figure 4. Dalapon remaining in Fayette medium silt loam (F5.1) and in three modifications after treatment with 120 ppm of dalapon and storage at a temperature of 30°C with the soil moisture at field capacity.

natural or limed soil, but decreased the overall rate over a period of 8 weeks.

As would be expected from the previous experiments, the decomposition of dalapon was found to vary in different types of soil in an experiment in which all other controllable factors were held constant and non-limiting. In this experiment, 120 ppm of dalapon and the necessary volume of water to bring each soil to the field capacity were added at room temperature. The jars of soil were then stored at 27° C. Bioassays were made after 2, 8, and 16 weeks of storage.

Figure 5 shows that decomposition was most rapid in the field limed Fayette medium silt loam (F6.5) and slowest in the unlimed (F5.1). These two soils differed primarily in pH, as indicated by the numerals in the abbreviations. The decomposition rate was intermediate and similar in Luton silty clay and Ida-Monona silt loam, but slower and at a more uniform rate in Webster silty clay loam. These results with soil which had been air-dried and stored prior to treatment should not be interpreted as precisely indicative of what could be expected under natural conditions, but do show the variability which might be encountered.

One of the last experiments conducted in the decomposition studies was intended to provide evidence on the relative importance of biological decomposition as compared to decomposition by possible chemical reactions. The soils used in this experiment included Ida-Monona silt loam, Fayette medium silt loam (F5.1), and F5.1 to which lime had been added in the laboratory. Both Fayette variates were obtained by compositing the appropriate untreated controls from the lime- and manure-addition experiment described previous-

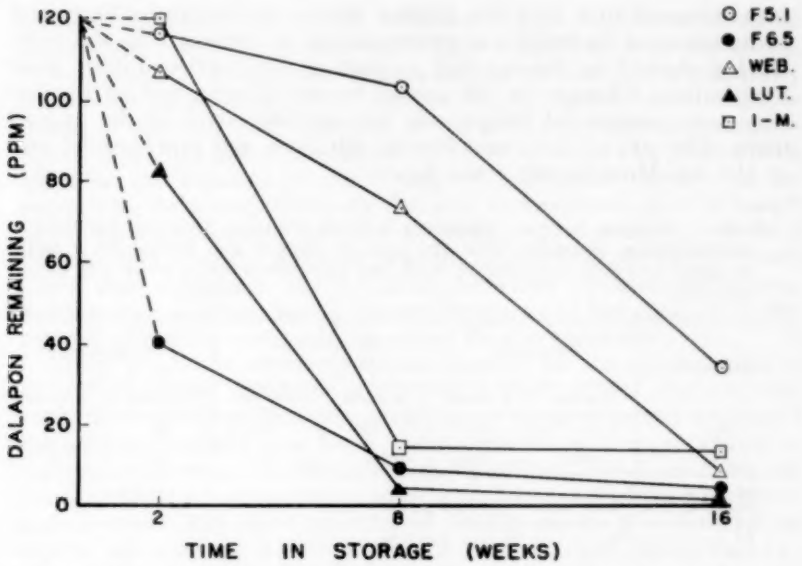

Figure 5. Dalapon remaining in five soil types after treatment with 120 ppm of dalapon and storage at a temperature of 27°C with the soil moisture at field capacity.

ly. The soil lots were weighed into petri dishes and the moisture content adjusted to 20 per cent. Two-third of the dishes of soil from each variate were autoclaved for 4 hours at 17 psi. Half of the autoclaved dishes were then recontaminated with 1 gram of untreated soil. The final quantity of soil in each dish was 20 grams on an oven-dry basis. All dishes of soil were then incubated for 1 week at room temperature to establish the growth of microflora in the recontaminated soils. Standard curves of millet response to known quantities of dalapon were prepared for all modifications of each soil variate. Some of the dishes were used for pH determinations or to log moisture levels during the course of the experiment.

At the end of the preliminary incubation, half of the dishes to be used in the main experiment received 120 ppm of dalapon under sterile conditions in sufficient water to bring the moisture level to 30 per cent. The others received only sterile water and were used as controls. After this the dishes of soil were placed in foil-covered cans and stored in a large can at room temperature. The relative humidity was kept at a high level by use of wet sand in the bottom of the large can, and by a covering of wet cheese cloth over the smaller cans containing the dishes of soil. Four replications were removed after 3 and 6 weeks for bioassays. At these times a few grains of soil from the treated dishes were placed in sterile petri dishes of potato-dextrose agar to check for the presence of microorganisms. Most of these checks were positive. The non-autoclaved and re-

contaminated soils had the highest degree of contamination; and contamination by fungi was predominant. In view of this, the autoclaving should be interpreted as partial sterilization rather than sterilization. Changes in pH caused by autoclaving and/or incubation were considered insignicant for the objectives of the experiment. The pH of the limed Fayette silt loam soil averaged 7.3 and of the Ida-Monona silt loam 8.1.

Table 3. Dalapon, in ppm, remaining in three soil types after two sterilizing modifications, treatment with 120 ppm of dalapon and storage for 3 and 6 weeks at room temperature with the moisture level at twice the field capacity.[1]

Soil type[3]	Sterilized[2]		Sterilized and recontaminated		Not sterilized	
	3 weeks	6 weeks	3 weeks	6 weeks	3 weeks	6 weeks
F5.1	—	120	92	6	45	1
F7.3	120	120	1	3	1	0
I-M	106	101	120	79	120	13

[1]Means of 4 replicates.
[2]Partial sterilization by autoclaving at 17 psi for 4 hours.
[3]F5.1—unlimed Fayette med. silt loam.
F7.3—unlimed Fayette med. silt loam plus lime.
I-M—Ida-Monona silt loam.

As shown in Table 3, partial sterilization stopped essentially all of the decomposition of dalapon in all three soils for at least 6 weeks. There was an indication of slight decomposition in the autoclaved Ida-Monona soil, but this could be the result of adsorption by the soil colloids. Recontamination of the sterilized soils largely offset the inhibition of decomposition by autoclaving in two soils, and to some extent in the third.

These data indicate the primary importance of microbiological activity in the decomposition of dalapon in soils, and for the soils studied, indicate that other mechanisms were relatively unimportant.

DISCUSSION

The studies reported here indicate that dalapon leaches readily, somewhat similarly to TCA (13, 16), and that it is rapidly decomposed under favorable conditions. In certain soil types, and under some artificially imposed modifications of several soil types and conditions, its decomposition was markedly inhibited.

From these data, it would be expected that the pre-emergence use of dalapon should be restricted to those crops on which dalapon is relatively non-toxic. On the other hand, its leaching and decomposition characteristics indicate that it has a high potential value for pre-planting control of weeds, and that residues will present little hazard of toxic accumulation with continued use at low rates, particularly in warm humid areas. These qualities, however, reduce its potential value for soil sterilization.

A high degree of retention of dalapon was not demonstrated in any of several soil types when the soils were moist and warm. It is

possible, however, that more retention might be encountered in other soils, particularly those with high anion exchange capacities.

It is postulated that the decomposition of dalapon is primarily a function of an unspecified fraction of the microbiological population of the soil. The direction of the change in rate of decomposition from any given modification would therefore depend on its effect on the segment of the biological population capable of decomposing dalapon. Although dalapon decomposed rapidly under favorable conditions, one could probably expect longer persistence in soils remaining dry for long periods, in cool soils, in soils at a pH other than optimum, or, in short, wherever environmental conditions were unfavorable for the proliferation of the segment of the biological population bringing about its decomposition.

There appear to be two possible theories for the explanation of the effects of the addition of organic matter. Either one or both could be operative. First, the addition of organic matter increased the substrate supply, and for a given population of microorganisms this would decrease the chances of any particular substrate molecule being utilized by an organism until a proliferation of the organisms had occurred. The effect on dalapon decomposition would therefore depend on how the added organic matter changed the proportion of organisms capable of utilizing dalapon to the number of molecules that were utilizable by these organisms. The second possible explanation requires a limitation on the number of types of organisms able to utilize dalapon. The addition of organic matter would increase the general population of microorganisms, with the possibility of non-utilizers of dalapon predominating. Under such a condition the competition between utilizers and non-utilizers could inhibit the initial proliferation of the utilizers of dalapon. As this competition proceeded the advantage could shift to the utilizers through limiting effects of the products of high activity, or by other mechanisms, thus permitting a proliferation of the utilizers that would be indicated by an increased detoxification of dalapon.

From the seemingly contradictory reports of several investigators (1, 5, 8, 12) relative to the effects of pH, liming and organic matter additions on the rate of detoxification of 2,4–D in soil, and from the studies reported here on dalapon, it becomes apparent that predictions of the persistence of herbicides that are decomposed as a result of biological activity may be entirely erroneous unless the effects of interacting factors are evaluated.

Soil temperature and moisture appeared to be the most critical of the indirect factors affecting the rate of decomposition of dalapon in the soil. At low temperatures and/or low soil moisture the decomposition of dalapon was essentially halted. With the other limiting factors, low pH and organic matter additions, inhibition appeared to be temporary. The Dow Chemical Company has reported (7) that dalapon in water solutions hydrolyzes slowly at ordinary temperatures, producing NaCl, HCl, and pyruvic acid. It is possible that microorganisms may detoxify dalapon by utilization and removal of the pyruvic acid resulting from hydrolysis of the dalapon,

thus speeding up the hydrolysis process. It is also possible that some organisms can utilize dalapon directly, thus eliminating the prerequisite of hydrolysis. No attempt was made in this study to specify which, if either, of these processes was responsible for the detoxification of dalapon.

SUMMARY

The response of soybeans grown in sections of soil columns previously treated with the equivalent of 24 lb/A of 2,2–dichloropropionic acid (dalapon) and then leached with 1.5 inches of water, indicated a high degree of mobility for the dalapon in several soil types. Additions of manure or sand altered the leaching characteristics of the soils to a small degree. Added manure decreased and added sand increased the mobility of the dalapon.

Various factors were studied to determine their effect on the decomposition rate of dalapon in soil. A bioasay, based on the response of germinating millet seedlings, was used to estimate the quantity of dalapon remaining in the soils after various intervals of time.

Data were obtained which indicate that the decomposition of dalapon in soils is primarily a function of an undetermined fraction of the microbiological population. Other factors influencing the decomposition rate were considered to act indirectly by affecting the activity of microorganisms in the soil. Low soil moisture, low pH, large additions of organic matter, and temperatures below 20 to 25° C inhibited the rate of decomposition. The soil type in which the highest rate of decomposition was found was a medium silt loam soil with low organic matter, that had been field limed to a pH of 6.5. The same soil type from a nearby unlimed area, still in forest, had the slowest decomposition rate of all the soils studied.

LITERATURE CITED

1. AKAMINE, E. K. Persistence of 2,4–D toxicity in Hawaiian soils. Bot. Gaz. 112:312–319. 1951.
2. ALDRICH, R. J. Herbicides; residues in soil. Jour. Agr. Food Chem. 1:257–260. 1953.
3. AUDUS, L. J. The decomposition of 2,4–dichlorophenoxyacetic acid and 2–methyl–4–chlorophenoxyacetic acid in the soil. Jour. Sci. Food Agr. 3:268–274. 1952.
4. BROWN, D. A. Residual effect of CMU, Dalapon, and Urab. Res. Report, North Central Weed Control Conf. pp. 3. 1954.
5. BROWN, J. W., and MITCHELL, J. W. Inactivation of 2,4–D acid in soil as affected by soil moisture, temperature, addition of manure and autoclaving. Bot. Gaz. 109:314–323. 1948.
6. DAVIS, F. L., and SELMAN, F. L. Effects of water upon the movement of dinitro weed killers in soils. Weeds 3:11–20. 1954.
7. DOW CHEMICAL COMPANY. Dalapon Bulletin No. 2. Dow Chemical Co., Midland, Michigan. 1953.
8. HANKS, R. W. Removal of 2,4–dichlorophenoxyacetic acid and its calcium salts from six different soils by leaching. Bot. Gaz. 108:186–191. 1946.
9. HARVEY, W. A., and CRAFTS, A. S. Toxicity of pentachlorophenol and its sodium salt in three Yolo soils. Hilgardia 21:487–498. 1952.
10. HERNANDEZ, T. P., and WARREN, G. F. Some factors affecting the rate of inactivation and leaching of 2,4–D in different soils. Amer. Soc. Hort. Sci. Proc. 56:287–293. 1950.

11. HILL, G. D., MCGAHEN, J. W., BAKER, H. M., FINNERTY, D. W., and BINGEMAN, C. W. The fate of substituted urea compounds in agricultural soils. Agron. Jour. 47:93–103. 1955.
12. KRIES, O. H. Persistence of 2,4–D acid in soil in relation to content of water, organic matter, and lime. Bot. Gaz. 108:510–525. 1946.
13. LOUSTALOT, A. J. Studies on persistence and movement of sodium trichloroacetate in the soil. Agron. Jour. 42:323–327. 1950.
14. ———, MUZIK, T. J., and CRUZADO, H. J. A study of the persistence of CMU in the soil. Agric. Chem. 8:52–53, 97–101. 1953.
15. NORMAN, A. G., and NEWMAN, A. S. The persistence of herbicides in soils. Proc. Northeastern Weed Control Conf. pp. 7–12. 1950.
16. OGLE, R. E., and WARREN, G. F. Fate and activity of herbicides in soils. Weeds 3:257–273. 1954.
17. RAI, G. S., and HAMNER, C. L. Persistence of sodium trichloroacetate in different soil types. Weeds 2:271–279. 1953.
18. SMITH, R. J., and ENNIS, W. B. Studies on the downward movement of 2,4–D and 3–chloro–IPC in soils. Proc. Southern Weed Conf. pp. 63–71. 1953.
19. SOUTHWICK, L. Progress report on agricultural uses of dalapon. Proc. Northeastern Weed Control Conf. pp. 251–256. 1954.

Translocation of Herbicides in Marabu. I. Translocation of 2,4,5–trichlorophenoxyacetic Acid Following Application to the Bark or to Cut-surfaces of Stumps[1]

J. R. HAY[2]

THE fast growing woody plant known as marabú, *(Dichrostachys nutans)*, is native to Africa but it has found a favorable environment in Cuba. At present, dense stands of it, 20 feet and more in height, cover vast areas of the island, and a great deal of land has had to be abandoned on account of it. The ease with which it becomes established in turf or in neglected sugar cane lends exceptional interest to the development of methods of controlling, or, if possible of eradicating the plant.

The customary method of marabú control in pastures, before the development of the newer herbicides, was to chop the suckers or ratoons with machetes. This gives only temporary relief because an outstanding characteristic of this plant is its ability to send up vigorous new shoots from the crown as well as from the horizontal and vertical roots. In general, the most effective method of controlling woody plants with herbicides has been the application of esters of 2,4–dichlorophenoxyacetic acid (2,4–D) and 2,4,5–trichlorochlorophenoxyacetic acid (2,4,5–T) in diesel oil to the basal areas of the stems or stumps, the so-called basal-bark treatments. However, as is well known now, although these treatments kill that part of the plant above the ground line, many species, including marabú, develop new shoots from surviving underground parts. It is evident that any really effective method of eradicating perennial plants must kill the underground parts capable of regeneration. For this reason the downward translocation of a herbicide is of the utmost importance. The present research was aimed at obtaining quantitative data on the amount of downward translocation, ascertaining the path of movement, and exploring the extent to which movement might be modified by the conditions of treatment. Part I reports on the translocation after application of the material to the bark or cut-surfaces of stumps, while Part II relates to translocation after foliage applications. Some of the work has been briefly described in a preliminary paper (6).

Most of the experimental work so far carried out indicates that the initial optimism as to the downward translocation of these herbicides was unjustified. Torrey and Thimann (13) painted small volumes of high concentrations of various herbicides on the cut-surfaces of long stumps of marabú. They concluded that movement downward was quite limited in as much as regrowth from the bases of the stumps often occurred. This conclusion was further strength-

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ened on testing extracts of various tissues from treated and untreated plants for 2,4–D. Although their experiments were only preliminary, they did not detect any downward movement into the roots.

A similar lack of downward movement has been found when the herbicides were applied to the bark of woody plants. Coulter (3) applied 2,4,5–T in an oil solution to the bark of dormant white oak *(Quercus alba)*. He treated the lower half of some trees, the upper half of others, and only the mid-section of still others. In the first case, all of the tree above the ground was killed, but in the second only the upper (treated) part died. In the last case, killing above but not below the treated section was observed. Meador and Fisher (9) treated the bark of mesquite *(Prosopis juliflora)* stems by fastening, with oil and water proof tape, bands of cotton which had been soaked in the herbicide solution being tested. The solutions of 2,4,5–T in oil gave the best kill of the stem above the treated area but "there was little evidence of movement below the point of application" regardless of the herbicide used. Blair and Glendening (2) filled "cups" fastened to the bark of dormant mesquite trees, with herbicide solutions. Uptake of the material was facilitated by making chisel cuts below the surface of the solution. Extensive upward movement and a maximum downward movement of 24 inches was reported.

MATERIALS AND METHODS

The method used here was essentially the same as that employed in the preliminary work by Torrey and Thimann (13). The fate of the herbicide was determined by extracting it from 3 to 4 gram samples of tissue taken from different parts of the plant after application. The amounts recovered in these extracts were assayed with the slit-pea test. These procedures, including the partial purification of the extracts, had been worked out in detail using bean seedlings and have been presented fully elsewhere (7). With this method, it was possible to determine quantitatively the amounts of the herbicide that moved to different parts of the marabú plant when it was applied: (1) to the bark of the stems (basal and mid-section), and (2) to the cut-surfaces of stems. The material used was the butoxyethanol ester of 2,4,5–T. Only the intact 2,4,5–T molecule is determined by this method since all or almost all of the breakdown products are inactive on the slit-pea test. The results reported here are either typical of several tests or averages of two or more trials as indicated.

RESULTS

Application to Bark. In these experiments, solutions of 2,4,5–T at concentrations of 8, 16, and 32 lb per 100 gal of diesel oil (approx. 10, 20, and 40 gr/liter) were applied to a zone 4 to 6 inches long on the bark of intact basal shoots. Enough material was applied (about 5 cc) so that the bark in that area was thoroughly wetted. Ratoons

(i.e. basal shoots) 4 to 6 feet high and ½ to ¾ inches in diameter at the base were used. Samples of bark and wood for testing were taken from the horizontal roots. These samples were about 3 to 4 grams fresh weight and were 4 to 5 cm in length. Since surface creepage along the stems were extensive when the herbicide was applied in oil, bands of absorbent cotton were fastened around the stems with oil and water resistant tape to stop spreading, and the samples were taken from beyond this point.

During the wet seasons (April to November) of 1952 and 1953 and the dry season (November to April) of 1953–54, 12 trials were made wherein the herbicide solution was applied to the basal parts of intact ratoons. Analyses of the root samples from just below the treated area all showed that no 2,4,5–T could be recovered from either the wood or the bark of the roots. These negative results were obtained regardless of the concentrations used (8 to 32 lb/100 gal) and regardless of whether the analysis was made at 6 hr, 16 hr, 2, or 13 days after application. The test was capable of detecting as little as 1–2 micrograms, or less than one one-thousandth of the amount applied (see ref. 7). Furthermore, in 3 other trials no activity was detected in the root samples when the solutions were applied to the bark of stumps rather than to the bark of intact plants. Analysis also showed that the use of water as the carrier was of no advantage in this respect. Two further tests wherein the 2,4,5–T was applied to the bark of the root itself also showed no downward movement. Hence the 2,4,5–T evidently did not move down from the stems to the roots following application to the bark.

Other tests were then made to see if there was a general lack of downward movement in the stems (i.e. not just from stem to root) when 2,4,5–T was applied to the bark in oil. For this, solutions were applied to a band about 6 inches wide located on the stem 2 to 3 feet above the ground. Slight swellings were found just below the treated area several weeks after application; these were similar to those previously noted below the treated surface of cut stumps (13). These swellings were probably induced by small, non-toxic amounts of the synthetic auxin which moved down over long periods of time. Otherwise, the response to these treatments was striking in that all those parts above the treated area were killed within a very short time, while the leaves and the stems below the point of application showed no toxic effects. This visual observation suggested strongly that the 2,4,5–T was not moving down, but for additional evidence, samples of wood and bark were taken from below and above the treated area and analyzed for 2,4,5–T. Table 1 shows results of 3 tests wherein no downward movement was detected at 1, 3 or 7 days. These results are typical of 7 different trials run at intervals ranging from 6 hours to 14 days after application of the 2,4,5–T. Thus, when applications of 2,4,5–T were made to the bark either at the base or part way up the stem neither toxic amounts of auxin, nor even amounts of auxin detectable by extraction, moved downward from the point of application.

Table 1. Recovery of 2,4,5–T when about 32 mg were applied to the mid-section of a stem of marabú. Samples were taken from 3 cm above and below the treated area, or from within the area.

Time, days after application	Sample		2,4,5-T recovered, μg per gram fresh weight	Percent of amount applied
	Location	Tissue		
1	Below	bark	0	0
		wood	0	0
	Above	bark	Trace	Trace
		wood	5	0.016
3	Below	bark	0	0
		wood	0	0
	Above	bark	3	0.009
		wood	12	0.037
7	Below	bark and wood	0	0
	Above	bark and wood	8	0.025
	Within	bark and wood	1530	5.0

Leaves and stems above the treated area of all these bark treatments were invariably killed, indicating that upward movement had taken place. Table 1 indicates the amount of upward movement. This upward movement, of course, shows that the auxin did penetrate the bark. In four mid-section treatments, wherein the wood and the bark were analyzed separately, the wood contained the greatest amount of the herbicide (see Table 1). Thus, although initially it was the bark that was treated, movement upward took place in the wood. The 2,4,5–T found in the bark probably came by lateral transport from the wood as shown for indole-acetic acid in herbaceous plants by Skoog (11) and for phosphate by Stout and Hoagland (12). Apparently, the 2,4,5–T when applied to the bark penetrates through the cortex into the wood whence it is carried up in the transpiration stream. In this respect, the results agree with previous findings with synthetic auxins in herbaceous plants where the upward movement is related to the transpiration stream and is limited to the wood.

As was already mentioned, the 2,4,5–T was applied in these trials as the butoxyethanol ester. It was of interest, therefore, to test whether the auxin recovered above the treated area was in the ester or the acid form. Table 2 shows that, when the neutral fraction (normally discarded) was tested for auxin, no activity was detected although activity was found in the acid fraction. This indicates that the 2,4,5–T moving in the plant had been converted to

Table 2. Recovery of 2,4,5–T in acid and in neutral fractions from samples of stem taken from above the treated area when 2,4,5–T was applied to the bark. Average of two trials.

Sample	2,4,5-T recovered, μg per sample	
	Acid fraction	Neutral fraction
Bark	1.5	0
Wood	12.0	0

the acid form. Similar tests were made on the samples taken from below the treated area, but none was found in either the neutral or acid fraction.

Further indications regarding the amount of 2,4,5–T transported was obtained in the following way. Since it was possible that there had been downward movement of small, non-toxic quantities of 2,4,5–T, lower than the minimum amount detectable in the extracts, a more sensitive criterion was desired. For this, the inhibition of lateral buds, measured as the delay in their elongation, was used. The sensitivity of these buds to inhibition by physiologically non-toxic concentrations of natural and synthetic auxins is well known, and 2,4,5–T is highly potent in this respect. Special care was again taken to stop the liquid from running down by fastening bands of absorbent cotton on the young ratoons about 6 to 8 inches above the ground. Enough 2,4,5–T in oil (at approx. 8 lb per 100 gal) was applied to wet thoroughly 4 inches of the stem above the stopper band. The tops of these ratoons were cut off 2 inches below the stopper band after different periods of time.

The first of these trials was started in the dry season of 1953–54. Eighteen days after treatment 100 per cent of the stumps which received no chemical treatment showed regrowth (bud development). Of those receiving treatment, but of which the tops had been removed at 1 and 4 days after treatment, 70 to 80 per cent also showed regrowth. When the treated tops were not removed, buds below the band displayed no new regrowth, indicating that enough downward movement was taking place over long periods of time to maintain inhibition of bud development. Thus, in this trial, little or no 2,4,5–T moved down from bark treatments within 4 days, although there was appreciable movement in 18 days if the tops were not removed. Other trials in both wet and dry seasons gave the same result.

In summary then; (a) toxic amounts do not move downward, (b) detectable amounts could at no time be extracted from below the treated area, and (c) not enough 2,4,5–T moved down from the bark treatments to inhibit all bud development when the treated part was removed one to four days after application. From these facts, it can be concluded that the immediate action of 2,4,5–T, as far as herbicidal concentrations are concerned, is limited to the area of contact and the region above to which the material is carried with the transpiration stream.

Because toxicity in the area of contact is a relatively non-specific characteristic, tests were made to compare the contact action of 2,4,5–T in oil with that of the oil alone. Ten stumps of marabú, 10 inches high and ¼ to ½ inch in diameter were treated with 10 drops of 2,4,5–T in oil at 8 lb per 100 gal and another ten stumps with plain oil. Ten drops were enough to wet approximately three quarters of one of these small stumps to run-off. After eighteen days the oil plus 2,4,5–T had killed, on an average, the top 7.4 inches of the stumps whereas oil alone produced no kill although some bark was discolored. At 66 days, however, the oil alone had killed

the stumps down 7.5 inches and the mixture down 8.1 inches. Essentially similar results were obtained in another trial with 2,4,5–T in oil at 4 lb per 100 gal and oil alone.

Thus, on marabú stems the oil alone had contact toxicity properties almost equal to those of 2,4,5–T in oil, except that the latter killed more quickly. Another difference was apparent in that there was no regrowth above the ground line on any of the stumps treated with 2,4,5–T in oil until 5 months after application, in contrast to the stumps treated with plain oil, of which 60% produced new shoots on the unkilled portion within 3 weeks. This confirms the preceding observation, that when the treated area is not removed small inhibitory amounts of the auxin apparently do move down over long periods of time. Nevertheless, all the plants, whether treated with herbicide plus oil or oil alone, eventually showed bud development and the only difference in effectiveness was in the rapidity of kill and in the time between treatment and the appearance of regrowth on the unkilled portion.

Application to Cut-surfaces. Freshly cut stumps may be killed by chemical treatments similar to the basal-bark method for intact plants, with the difference that on stumps the material has two means of entering, namely, through the bark and through the cut-surface. As was shown in the previous section, there was no downward movement of the herbicide when it was applied only to the bark. The tests reported here were made to see if the material would move down from cut-surfaces.

In the first of these trials, 0.4 to 0.5 cc of 20% solutions of 2,4,5–T (ca 80–100 mg of 2,4,5–T) were applied to the freshly cut surfaces of stumps about one foot long and about ½ inch in diameter. Samples of the wood and bark of the trunk about 3 or 4 gram fresh weight and about 4 cm long were tested for 2,4,5–T. Results of such trials showed positive tests for the auxin in the stems well below the cut-surfaces, indicating real downward movement (Table 3). A similar downward movement of the 2,4,5–T into the roots was detected when the solution was applied to the cut-surfaces of short stumps (Table 4).

Table 3. Recovery of 2,4,5–T from stems when 80 mg were applied to the cut-surfaces of long stumps (1 foot) of marabú. All figures are the average of two trials.

Time, days after treatment	Distance of sample below cut-surface	Tissue	2,4,5-T μg sample	2,4,5 T μg/gram fresh weight
2	6–9 cm	Bark	14	1.2
		Wood	32	12.0
3	16–19 cm	Wood	16	5.3
5	16–19 cm	Wood	28	7.5
7	16–19 cm	Bark	0	0
		Wood	20	5.9
90	6–9 cm	Wood	1	0.5

Table 4. Recovery of 2,4,5–T from the wood of roots after about 80 mg had been applied to cut-surfaces of short stumps (5 cm) in oil.

Time, days after treatment	Date	Distance below cut-surface	2,4,5-T µg/sample
5	Sept. 1952	11–14 cm	3
4	Sept. 1952	15–18 cm	10
1	July 1953	12–15 cm	ca 40
1	July 1953	18–22 cm	10

In Table 3 where the wood and the bark were analyzed separately more 2,4,5–T was recovered from the wood than from the bark. After 7 days, none was recovered from the bark. Amounts found at a given level in the wood, on the other hand, remained high for a week. It seems probable, therefore, that the downward movement took place in the wood with subsequent lateral movement to the bark.

In some preliminary trials, it was noted that Sudan IV in oil and safranin in water were taken up readily from cut-surfaces of stems. When the root systems of these plants were examined upon excavation, the dyes were found in the vessels. A similar movement of dyes has been reported in the coffee plant (1). This observation accounts for the fact that downward movement of the herbicide from cut-surfaces took place in the wood. Apparently, the herbicide solution travels down as a mass flow in the vessels.

It is recognized that negative pressures exist in the xylem while plants are actively transpiring. Thus, if a solution is applied to a cut-surface immediately after cutting it might be expected that some would be "sucked" down into the plant. Furthermore, the solution would continue to enter until the pressure within the xylem equalled the atmospheric pressure. The behavior of the dye when applied immediately after cutting was therefore compared with its behavior when applied five minutes later. It was found that the dye solution would move down an average of 6 to 8 inches within ½ minute when applied to a freshly cut stump, but, if 5 minutes were allowed to elapse between time of cutting and application, the dye moved only about one inch within the first ½ minute. In all the tests on the application to cut-surfaces mentioned above, care had been taken to make application as soon after cutting as possible. It seemed likely, therefore, that the descent of the solutions was due, at least partially, to the low pressures in the wood.

DISCUSSION

The results from these two methods of application show a general parallelism but with some divergences. It is clear that toxic amounts of 2,4,5–T did not move down following application to the bark even when applied in good volume and in extremely high concentrations, and regardless of whether oil or water was used as the carrier. If the treated area was removed, regrowth from the stumps or roots appeared almost immediately, but when not removed ap-

parently small non-toxic amounts did move down to inhibit development of buds. The shoots that developed from these buds appeared to be morphologically normal. In contrast, toxic amounts of the auxin did move upward, travelling in the wood and doubtless with the transpiration stream. As a result, the part of the plant above the lowest point of application was killed whereas the part below was not.

Quite large amounts of 2,4,5–T moved downward from cut-surface applications but only in the wood. The evidence suggests that when the herbicide solution was applied quickly after cutting it moved down through the xylem vessels because of the negative pressures existing in the wood at the time the tops were removed. In both the basal-bark and the cut-surface methods of application there was no movement of detectable amounts of auxin through the phloem or cortex and the movement that did occur took place in the non-living part of the stem. These data strongly suggest that the mechanism responsible for active translocation of 2,4,5–T in the stems is disrupted by the applied auxin itself. The same conclusion was drawn from experiments on transport after foliage application of 2,4–D to marabú (4) and in bean seedlings (5, 8).

Basal-bark applications give complete top-kill and good root-kill of marabú with one treatment. The results herein confirm the view (10) that the key to success with this method is the application of sufficient material at the ground line to insure that phytotoxic quantities run down along the *outside* of the roots. For complete eradication, repetitions of the treatment will kill new shoots, and living portions of roots surviving the first treatment. Cut-surface treatments of stumps are promising because toxic quantities move down *within* the plant, and because water may be used as the carrier instead of oil. However, this method of application is not convenient for large scale operations, because of the difficulty of applying sufficient solution on the flat cut-surface to insure extensive downward movement. Further work with this method may make it more practical.

SUMMARY

Direct measurements were made of the amount of 2,4,5–T that was transported in a woody plant after it was applied to the bark and to cut-surfaces of stumps. A highly sensitive bioassay which had been first worked out with seedlings in the laboratory was used. None of the herbicide was found to move downward after application to the bark, although when applied in oil relatively large amounts did penetrate. Some of the material that penetrated in as far as the wood was carried upward in the transpiration stream. Large amounts moved down when applied to cut-surfaces of stumps. This movement occurred in the wood rather than the bark. Phytotoxic amounts of these herbicides did not move through living tissues of this plant following any of the application methods. The significance of these results to the practical control of marabú is discussed.

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LITERATURE CITED

1. ARNDT, C. H. The movementof sap in *Coffea arabica* L. Am. J. Bot. 16:179–190. 1929.
2. BLAIR, O. B., and GLENDENING, G. E. Intake and movement of herbicides injected into mesquite. Bot. Gaz. 115:173–179. 1954.
3. COULTER, L. L. Two primary factors influencing results in the control of oak during dormant period. Proc. North Central Weed Control Conf. p. 76. 1951.
4. HAY, J. R. Translocation of herbicides in marabú. II Translocation of 2,4–dichlorophenoxyacetic acid following foliage applications. Weeds (in press).
5. ———. The effect of 2,4–dichlorophenoxyacetic acid and triiodobenzoic acid on the transport of indoleacetic acid. Plant Physiol. (in press).
6. ———, and THIMANN, K. V. Translocation of 2,4,5–T in Cuban marabú. Proc. Northeastern Weed Control Conf. p. 303. 1953.
7. ———, and ———. The fate of 2,4–D in bean seedlings. I. Recovery of 2,4–D and its breakdown in the plant. Plant Physiol. (in press).
8. ———, and ———. The fate of 2,4–D in bean seedlings. II. Translocation. Plant Physiol. (in press).
9. MEADORS, C. H., JR., and FISHER, C. E. Absorption and translocation of 2,4–D and 2,4,5–T when applied to bark of mesquite stems. Res. Report, North Central Weed Control Conf. p. 67. 1953.
10. Recommendations of Research Committee. Proc. North Central Weed Control Conference. p. 66. 1953.
11. SKOOG, F. Absorption and translocation of auxin. Am. J. Bot. 25:361–372. 1938.
12. STOUT, P. P., and HOAGLAND, D. R. Upward and lateral movement of salt in certain plants as indicated by radioactive isotopes of P, Na and K absorbed by roots. Am. J. Bot. 26:320–324. 1939.
13. TORREY, J. G., and THIMANN, K. V. Application of herbicides to cut stumps of a woody tropical weed. Bot. Gaz. 111:184–192. 1949.

Some Factors that Affect the Phytotoxicity of Water-soluble DNBP[1]

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The alkanolamine salts of 2,4–dinitro–o–secondary butyl phenol (DNBP) have been used frequently as a pre-emergence herbicide in cotton without causing injury. However, under some conditions the chemical has severely reduced the stand. This paper presents data that show the effects of rainfall, lime, soil type, and temperature on the phytotoxicity of dinitro to cotton seedlings.

Procedure

Experiments were conducted (1) in outdoor plots that could be covered by movable sheds in case of rain, (2) in lysimeters that could also be covered, and (3) in the greenhouse in galvanized metal flats that could be irrigated from below. No experiment received surface watering except where indicated.

Deltapine 15A cotton was used as the test plant in all experiments. Except where noted to the contrary, the soil was a Norfolk sandy loam, the planting depth 0.75 inches, and the maximum daily soil temperature usually 90°F. or more. In every case a good seedbed was prepared, and the seed were planted at the rate of 2 per inch of row. This made a total of 240 seed for the outside plots, 76 for the greenhouse plots, and 50 for the lysimeters. Immediately after planting the seed and compacting the soil, the DNBP was applied at a predetermined rate on a 12-inch band. The DNBP was applied with a specially designed electrically driven spray rig that travelled on a portable track. The spray machine was calibrated before each experiment, and the rate of application of DNBP was confirmed by laboratory analysis of samples taken in the row. Soil and air temperatures were taken three times each day except in experiments directly concerned with temperature effects. In these experiments temperatures were recorded hourly.

Stand counts were made each day for the first 3 or 4 days after emergence and at least twice a week for the next 2 weeks. Three kinds of information were collected; the number of plants emerging, the number of plants living at the end of the experimental period, and the percentage of the emerged plants that died. All of the tabular data given are averages from four replications except where noted to the contrary. Before analysis, the values for the percentages killed were transformed to angles (arcsin $\sqrt{\text{percentage}}$) as proposed by Snedecor (8).

The first four experiments dealt with the effects of various times

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and amounts of simulated rainfall on the phytotoxicity of DNBP. The first three were conducted in the outdoor plots and the fourth in the lysimeters. The fifth and sixth experiments, also in outdoor plots, were studies of the effects of lime and of lime plus simulated rainfall. The seventh experiment was a greenhouse experiment involving the effect of soil type. The eighth and ninth experiments were temperature studies conducted in the greenhouse. The temperatures were elevated by 125 watt and 250 watt infrared lamps. One lamp was centered over each flat. The temperatures were controlled by changing the elevation of the lamps and by shutting them off for short intervals.

RESULTS

In experiment 1, eight rows of cotton were treated with 4.5 pounds of DNBP per acre. When the cotton had just commenced to emerge, four randomly selected rows received 0.5 inch of simulated rainfall from a sprinkling can. In rows that received no water 76% of the emerging cotton was killed, while only 39% was killed in those that received 0.5 inch of water. Likewise those receiving no water had an average of 41 plants surviving per row while those receiving water had 81 plants per row. The probability of these results being due to chance alone was less than 0.005.

In experiment 2, 0.5 inch of water was applied 6 hours after planting, on the day the cotton emerged, and 3 days after emergence. Additional plantings received no water. All watering treatments were applied randomly to both DNBP treated and untreated rows. Experiment 3 was a duplicate of the second experiment except that two more waterings were included. These were 48 and 72 hours after planting. The cotton emerged 96 hours after planting. The results of these two experiments are combined in Table 1.

Since the significant interaction between water and DNBP found in experiment 2 was not repeated in experiment 3, the results of both experiments were combined and reanalyzed. The combined analysis showed a significantly higher percentage kill (5 percent level) when the water was applied three days after the cotton had emerged as compared with other times of application.

In experiment 1 it was found that water on the day of emergence decreased the percentage kill as compared with no water. The results of experiments 1, 2, and 3 were combined and analyzed for this comparison. This analysis showed that the percentage kill was significantly reduced (1 per cent level) when water was applied on the day of emergence.

Experiment 4 dealt with the effects of depth of planting and amount of simulated rain on toxicity of the compound. Six hours after planting, water was applied by means of a sprinkler system. Distribution and amounts of the water were checked with rain gauges. The results are given in Table 2.

Experiment 5 was concerned with the effects of time and form of application of slaked lime on the toxicity of DNBP. The per acre rates used were 6 pounds of DNBP and 50 pounds of lime. The lime

Table 1. The effect of applying 0.5 inch of simulated rain at various times on the phytotoxicity of DNBP to cotton seedlings.

Time of water application	DNBP lb/A	Seedling response		
		Ave. no. emerging	Ave. no. surviving	Ave. pct. killed
Experiment 2[1]				
6 hours after planting	0.0	186	178	4
6 hours after planting	4.5	149	91	38
Day of emergence	0.0	184	174	5
Day of emergence	4.5	154	108	31
3 days after emergence	0.0	179	169	5
3 days after emergence	4.5	174	43	77
No water	0.0	169	159	6
No water	4.5	169	101	41
Experiment 3[2]				
6 hours after planting	0.0	183	173	6
6 hours after planting	4.5	179	117	36
48 hours after planting	0.0	192	181	6
48 hours after planting	4.5	181	148	18
72 hours after planting	0.0	191	180	6
72 hours after planting	4.5	187	137	26
Day of emergence	0.0	193	183	5
Day of emergence	4.5	190	149	22
3 days after emergence	0.0	194	177	8
3 days after emergence	4.5	185	104	44
No water	0.0	186	175	7
No water	4.5	191	141	26

[1]Probability values: DNBP<0.005, time water applied<0.01, water × DNBP<0.025.
[2]Probability values: DNBP<0.005, time water applied>0.10, water × DNBP>0.10.

Table 2. The effects of depth of planting and amount of rainfall on phytotoxicity of DNBP to cotton seedlings.

DNBP lb/A	Depth of planting inches	Number of inches of water				
		0.00	0.25	0.50	1.00	2.00
		Average number of seedlings emerging[1]				
0.0	0.75	32	27	36	34	38
0.0	1.50	36	40	40	39	42
9.0	0.75	30	4	0	4	13
9.0	1.50	27	3	8	24	28

[1]Probability values: Water level<0.005, DNBP × water level<0.005, depth of planting<0.005, depth × DNBP>0.5, depth × DNBP × water level>0.5.

was applied both as a spray and as a dust 1 to 2 hours before, 1 to 2 hours after, and 3 days after the DNBP application. Additional rows received no lime with the DNBP and others received neither lime nor DNBP. The results are given in Table 3.

Experiment 6 was a study of the effect of simulated rainfall on the safening action of lime. The lime was applied to the row 1–2 hours before the DNBP application, and the 0.5 inch of water was applied three days after emergence. The lime was applied as a dust, and the rainfall was simulated as in experiment 4. The results are given in Table 4.

Table 3. The effects of various forms and times of application of lime on the phytotoxicity of DNBP to cotton seedlings.

DNBP lb/A	Form of lime and time of application with reference to the DNBP	Seedling response		
		Ave. no. emerging	Ave. no. surviving	Ave. pct.[1] killed
0.0	none applied	175	158	10
6.0	none applied	158	45	72
6.0	spray 1–2 hr. before	158	102	36
6.0	spray 1–2 hr. after	168	116	32
6.0	spray 3 days after	156	117	25
6.0	dust 1–2 hr. before	169	124	27
6.0	dust 1–2 hr. after	159	126	18
6.0	dust 3 days after	154	113	27

[1]Probability values: DNBP<0.005, lime<0.005, time of application<0.10, time × form <0.05.

Table 4. The effects of water and lime on the phytotoxicity of DNBP to cotton seedlings.

DNBP lb/A	Water inches	Lime lb/A	Seedling response		
			Ave. no. emerging	Ave. no. surviving	Ave. pct.[1] killed
0	0.0	0	170	157	7
0	0.5	0	164	149	9
0	0.0	100	166	154	7
0	0.5	100	160	142	11
6	0.0	100	156	101	36
6	0.5	100	164	99	40
6	0.0	0	151	51	68
6	0.5	0	156	41	74

[1]Probability values: DNBP<0.005, water>0.10, lime × DNBP<0.005, lime × water>7.5, lime × DNBP × water>7.5.

Experiment 7 was designed to determine whether the soil type had any effect on the toxicity of DNBP to the cotton seedlings. The chemical was applied to a Deer Creek silt loam and a Norfolk sandy loam soil at the per acre rates of 6 and 9 pounds. The DNBP was then thoroughly mixed with the top 4 inches of soil. Cotton seed were planted in the chemically treated soils and in untreated checks. The average per cent of plants emerging in the Deer Creek soil were 75, 75, and 73 on the check, 6, and 9 pound rates, respectively. The per cent of plants on the Norfolk were 80, 68, and 3. Analyses of the data gave the following probability values: soil <0.005, DNBP rates <0.005, and soil x DNBP rates <0.005.

The chemical properties for the Deer Creek as compared with the Norfolk soil were: cation exchange capacity 14.16 vs. 2.51, exchangeable calcium 9.62 vs. 1.25, per cent calcium saturation 67.9 vs. 29.8, exchangeable potassium 0.425 vs. 0.153, exchangeable sodium 0.326 vs. 0.182, pH 5.65 vs. 6.00, and per cent organic matter 0.81 vs. 1.14. In each case the value for the Deer Creek soil is given first. The exchange capacities are expressed in m.e. per 100 g.

Experiments 8 and 9 were designed to determine whether temperature had any effect on phytotoxicity and whether infrared lamps

could be substituted for the sun in bringing about the temperature response. All treatments were kept in the shade until the third day after emergence. On that day the plants were subjected to the various controlled temperatures. At the end of a 2-day treatment period, all plants were again placed in the shade. In experiment 8, the effects of temperature elevation by the sun were compared with infrared lamps. Experiment 9 was a continuation of the study of the effect of heat on phytotoxicity. Three heat levels were achieved in the greenhouse by the use of no supplemental heat, heat from 125 watt infrared bulbs, and heat from 250 watt bulbs. The results of experiments 9 and 10 are given in Table 5. The values from experiment 9 are averages from nine replications.

Table 5. The effect of various heat levels on the phytotoxicity of DNBP to cotton seedlings with a comparison of the effects of the sun versus infrared lamps as the source of heat.

DNBP lb/A	Heat source	Temp. °F.	Seedling response		
			Ave. no. emerging	Ave. no surviving	Ave. pct. killed
		Experiment 8[1]			
0.0	Shade	81	70	66	5
4.5	Shade	81	67	55	18
0.0	Sun	93	67	62	8
4.5	Sun	93	66	34	48
0.0	250 W. infrared	95	70	68	2
4.5	250 W. infrared	95	66	38	43
		Experiment 9[2]			
0.0	Shade	84	68	65	4
4.5	Shade	84	66	55	18
0.0	125 W. infrared	90	66	65	1
4.5	125 W. infrared	90	63	44	30
0.0	250 W. infrared	96	65	64	2
4.5	250 W. infrared	96	66	21	69

[1]Probability values: DNBP<0.005, shade vs. other<0.005, DNBP × heat<0.025, DNBP × kind of heat>0.5.
[2]Probability values: DNBP<0.005, heat levels<0.005, DNBP × heat<0.005.

DISCUSSION

Results of field trial with pre-emergence type chemicals have been characterized by a great deal of variability. Some of the causes for variable results with DNBP were shown in these experiments. The time when rain occurs, amount that falls, soil type, amount of free lime, and temperature all affected the phytotoxicity of DNBP. Furthermore, interactions were shown to exist between some of these factors.

This variability in phytotoxicity involved two separate modes of action. The first resulted in decreased numbers of seedlings emerging. This was caused by the killing of the germinating cotton seed by a high concentration of DNBP in the seed zone. Davis et al. (4) found that large amounts of DNBP can be moved into the seed zone by the leaching action of rain. Decreased emergence induced by rain would be expected to occur only if: the leaching occurred before the seed had germinated; the leaching was enough to move

the DNBP down to, but not beyond, the seed zone and there was sufficient concentration of DNBP on the surface to bring the concentration in the seed zone to a toxic level. These conditions were found only in experiment 4. The water was applied too late in experiments 1, and 6 to leach the chemical down around the seed before it germinated. In experiment 2, water applied 6 hours after planting reduced germination, but this reduction was not repeated in experiment 3 (Table 1). It was assumed that not enough chemical could be leached from the relatively small amount on the surface to consistently depress the germination of the cotton. Consequently, the per acre rate of application of DNBP was raised from 4.5 pounds to 9.0 pounds in experiment 4. When 9 pounds of DNBP was used, even 0.25 inch of rain 6 hours after planting greatly reduced emergence (Table 2).

Much of the variability in phytotoxicity of DNBP to cotton has been attributed to variations in soil type. Consequently, two widely different soil types were compared in experiment 7. The Deer Creek silt loam was imported from a field in Mississippi where very little DNBP injury had been observed, and the Norfolk sandy loam was a local soil type on which injury had been produced repeatedly. The DNBP was thoroughly mixed with the top 4 inches of soil to insure that the germinating seed were actually in contact with a known concentration of DNBP. The greatest difference was present at the 9-pound rate where 75% emerged in the Deer Creek soil and only 3% in the Norfolk. No attempt was made to correlate this difference with any one of the soil characteristics.

The second mode of action involves killing the cotton, by DNBP vapor, after it has emerged. This type of action is a much greater hazard in the field than the first. Various aspects of killing by DNBP vapor have been discussed by other workers (1, 2, 3, 5, 6, 7, 9). Hollingsworth (5) has shown that cotton is only slightly susceptible to this kind of injury on the day of emergence, that it reaches a peak of susceptibility 5 to 8 days after emergence, and that it then becomes again less susceptible. Here again, rainfall plays an important role both in the increase and in the decrease of injury by DNBP vapor. One would expect that, if rain fell after the cotton had germinated but before it had reached the time of high susceptibility to vapor injury, the hazard would be decreased by lowering the concentration of DNBP on the surface. This was confirmed in experiments 1, 2, and 3. In each of these experiments, rain on the day of emergence decreased the percentage of emergent cotton that was killed. The reduction was significant only in experiment 1, but combined analysis of the three experiments showed that there was less than one chance in one hundred that this repeated reduction was due to chance alone. No doubt, larger amounts of rainfall would have made this action more obvious. Furthermore, one would expect that a light shower accompanied by high temperatures during the period of high susceptibility to injury would increase the hazard, since more chemical will volatilize from a moist than from a dry

soil surface (3). Combined analysis of experiments 2 and 3 showed this increase to be significant at the 5 per cent level.

In experiment 5, lime dust and spray were used in an attempt to decrease vapor injury. Analysis of variance (Table 3) showed a highly significant reduction in percentage kill after emergence when 50 pounds of lime per acre were used with the relatively high per acre rate of 6 pounds of DNBP. The time of application of the lime, from just before treatment with DNBP until 3 days after treatment, did not have a significant effect on this reduction in toxicity. Hollingsworth (5) has observed a similar decrease in vapor injury by the use of lime. Since earlier experiments showed that a maximum hazard was associated with rain 3 or 4 days after emergence, rain was used at this time in experiment 6. The data in Table 4 show that the lime was very effective in reducing the toxicity with or without rain.

Other workers (2, 5) have demonstrated that the volatility of DNBP is affected by temperature. Experiments 8 and 9 were an attempt to show that the laboratory observations of greater volatility at higher temperatures could be extrapolated to greater kill in the field at higher temperatures. Experiment 8 was designed to show that temperature effects on phytotoxicity that were produced by the sun were similar to those induced by infrared heating lamps. Analysis of the data showed that, while there was a highly significant effect of increased temperature, the source of the increase was not significant (Table 5).

From the results of experiment 8, it seemed reasonable to assume that infrared lamps could be substituted for the sun as a source of heat in studies of the effect of temperature on phytotoxicity. Experiment 9 was designed to measure these effects. This experiment showed that under those particular conditions some injury occurred at an average daytime temperature of 84° F. and that the amount of injury increased rapidly to nearly 70% kill at 96° F. There appears to be a rather narrow temperature range over which a very large difference in phytotoxicity will result.

SUMMARY

The phytotoxicity of dinitro–o–secondary butyl phenol to cotton was investigated under various environmental conditions.

1. Rain, a few hours after planting, may leach sufficient DNBP down around the seed to reduce germination, but this occurred only when relatively high rates of DNBP were used. Rain, after germination and before the cotton is well out of the soil, may leach some DNBP from the surface and decrease the kill of emergent plants by vapor burn. Rain, 3 or 4 days after emergence, may increase vapor activity and kill. The above statements were true for 0.5 inch of simulated rain, but they would not necessarily be true for a very light or very heavy rain.

2. Slaked lime, applied at 50 pounds per acre either as a dust or a spray any time prior to cotton emergence, significantly reduced the

kill of cotton after emergence. This reduction was not decreased by 0.5 inch of rain 3 or 4 days after emergence.

3. DNBP was less toxic to cotton planted in Deer Creek silt loam soils than in Norfolk sandy loam.

4. A relatively small increase in temperature from 84 to 96° F. increased the percentage of plants killed from 18 to 69, respectively.

LITERATURE CITED

1. BARRONS, C. K., LYNN, G. E., and EASTMAN, J. D. Experiments on the reduction of high temperature injury to cotton from DNOSBP. Proc. Southern Weed Conf. pp. 33–37. 1953.
2. DAVIS, D. E., and DAVIS, F. L. Some effects of rainfall and lime on the phytotoxicity of water soluble dinitro. Proc. Southern Weed Conf. pp. 208–211. 1954.
3. DAVIS, F. L., SELMAN, F. L., and DAVIS, D. E. Some factors affecting the behavior of dinitro herbicides in soils. Proc. Southern Weed Conf. pp. 205–207. 1954.
4. ————————. Effects of water upon the movement of dinitro weed killers in soils. Weeds 3:11–20. 1954.
5. HOLLINGSWORTH, E. B., and ENNIS, W. B., JR. Some studies on vapor action of certain dinitro compounds upon young cotton plants. Proc. Southern Weed Conf. pp. 23–31. 1953.
6. ————————. Effect of soil pH on activity of DNOSBP. Proc. Southern Weed Conf. pp. 212–218. 1954.
7. SHAW, W. C., LINDLER, P. J., and MARTH, P. C. The importance of the relative vapor activity of chemicals in the development and use of herbicides. Proc. Southern Weed Conf. pp. 45–46. 1953.
8. SNEDECOR, G. W. Statistical methods. Iowa State College Press. 1946.
9. SWANSON, C. R., SHAW, W. C., and HUGHES, J. H. Some effects of isopropyl N-(3 chlorophenyl) carbamate and an alkanolamine salt of dinitro ortho secondary butyl phenol on germinating cotton seeds. Weeds 2:178–189. 1953.

Aquatic Weed Control Practice in Potable Water Supply Reservoirs

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INTRODUCTION

AQUATIC weed control in storage reservoirs and conveyance systems of certain domestic water supply systems is a challenging problem to the waterworks engineer. The problem concerns not merely the control or elimination of aquatic growths. It involves water quality factors which may be inconsequential in other phases of aquatic weed control, but are of major importance in drinking water supplies. Where adequate treatment facilities are available, water quality factors are subject to control. However, many domestic water supply systems lack treatment facilities, and the effect on water quality by the use of any materials in the supply must be subjected to critical review.

California cities with limited local water supplies have had to develop distant sources of water supply, and transport those supplies through extensive conduits to local storage reservoirs to satisfy their water demands. The City of San Francisco has developed a source of supply on the west slope of the Sierras 200 miles distant from its consumer area. Los Angeles has developed a similar source of supply on the east slope of the Sierras 350 miles distant. The Metropolitan Water District of Southern California imports water from the Colorado River and distributes it to the forty-five member cities of the district through a conveyance system 457 miles long.

These three major water supply systems in California have similar reservoir and conduit systems with typical operational problems. Both the San Francisco supply and the Los Angeles supply are obtained from the winter snow crop of the Sierras. The supplies are collected in impounding reservoirs and transported to local distribution reservoirs under such conditions as to preclude any possibility of gross pollution and to protect the original high quality of the supply. Except for softening treatment of a portion of the Metropolitan Water District supply, normal treatment of these three supplies is limited to chlorination for bacterial control and copper sulphate treatment for algal control.

The growth of aquatic weeds in the reservoirs and conduits of untreated domestic water supply systems produces problems in the maintenance of water quality and the operation of the system. Weed growths in the conveyance system reduce capacities to critical limits where increasing demands are already taxing those capacities. Weed growths in the reservoirs cause numerous problems. The presence of aquatic weeds produce an unsightly appearance from an esthetic standpoint. They form a harborage for many forms of insect life which occasionally find access to the distribution system to the con-

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sternation of the consumer. As a food supply, aquatic weeds attract waterfowl which contribute a heavy organic pollutional load to the supply. More serious effects develop when the plants die off. The large masses of dead material settling to the bottom of the reservoirs produce from their own components or by bacterial action, decomposition products adversely affecting water quality. Sloughing material from weed growths, floating to the shore, becomes a possible source of fly breeding and odors. This floating material can also clog screens on the outlet tower, or passing the screens, clog appurtenances such as meters and regulators in the distribution system, and in addition become a source of consumer complaints.

Aquatic weed control has always been a serious problem to the waterworks industry. In 1935, Arnold (2) presented the general methods of weed control practice at that time. His concluding statement was: "The subject of weed control is one of interest to waterworks men and is worthy of further study and experimentation." Over twenty years have passed without any material change in aquatic weed control practice in the domestic water supply industry.

Although there has been intense activity in the development of chemical herbicides which have found extensive application in the industrial and agricultural fields, little progress has been noted in the control of aquatic weeds in untreated domestic water supply systems. Mechanical means are still the most predominant method of aquatic weed control. Various methods are used to remove growths when they reach a stage that they become an operational nuisance. Weeds along the shallow areas of reservoirs may be removed by lowering the water level and exposing the growths to the air. Then the weeds may be raked, disced under, or burned with a flame thrower after being sprayed with oil. Another method employs the use of underwater mowers or a cable to cut off the growth after which the weeds must be removed manually. Other variations of mechanical control are employed which are only expensive, laborious, palliative measures accomplishing little in eliminating or adequately controlling aquatic growths.

Many chemical products are available that affect aquatic weeds, such as the arsenicals, chlorinated hydrocarbons, and numerous patented commercial products. These products have found application in the control of various aquatics in many fields. Their application to the problems of the domestic water supply industry, however, is limited by many restrictions. Arsenicals requiring from 3 to 10 parts per million dosages for effective control greatly exceed the drinking water standards of the United States Public Health Service of 0.05 parts per million for arsenic. Products such as the chlorinated hydrocarbons produce tastes and odors which cannot be eliminated where water treatment facilities are not available. Other products showing promise may have to pass the requirements of the Food and Drug Administration for toxicity before finding application in the waterworks industry. The economic aspects and availability of supply have to be considered, particularly with the

introduction of new products with limited production. Finally, public reaction to the use of certain materials often has a strong influence on their application.

The Department of Water and Power of the City of Los Angeles has had a persistent problem in the control of aquatic weeds in the reservoirs and conduits of its water supply system. There are 26 open reservoirs in the system ranging in capacity from 10 to 183,000 acre-feet storage, and located in elevation between 378 feet and 7,130 feet above sea level. Various types and quantities of aquatic vegetation are found in these many reservoirs. However, only a few species have caused any serious problems due to excessive growths. *Cladophora* frequently develops along the shorelines of the reservoirs and in the open conduits. It readily responds to light treatments of copper sulfate and is not a serious problem when promptly treated. *Myriophyllum* is also found in some of the smaller reservoirs. On one occasion an excessive growth of *Myriophyllum* developed in one reservoir, but the problem was eliminated by reconstruction of the reservoir before any investigation could be made in regard to control measures. It has persisted in another reservoir in limited amounts throughout the growing season despite a continuous chlorine residual of 0.15 part per million.

The most critical problem in aquatic weed control in the reservoirs of the Department's system are pondweeds, particularly *Potomogeton panorimitanus* and *Zanichellia palustris*. The records show that pondweed growths have always been an obstinate operational and water quality problem to operators of the Department's reservoir facilities. Many theories were propounded as to the cause of excessive growths, and ideas presented for the solution of the problem without any progress in effective control.

METHODS AND RESULTS

In 1948 the Water Quality Section of the Sanitary Engineering Division began investigating the possibility of controlling pondweed growths with copper sulfate. Copper sulfate pentahydrate ($CuSO_4 \cdot 5H_2O$) containing 25 per cent metallic copper has been the principal algicide of the waterworks industry. The concentration of copper produced in water under normal treatments will not begin to approach the limit of 3 parts per million set by the United States Public Health Service standards. Experience in algae treatment showed that intermittent treatments under 0.5 parts per million normally used were ineffective on pondweed growths. Further experiments showed that intermittent treatment as high as 100 parts per million on monthly, bimonthly, or trimonthly schedules were also ineffective. The method of treatment in the second case was to scatter large crystals of copper sulfate among the plants growing coves. These crystals, dropping to the bottom of the reservoir, would produce a strong concentration of copper sulfate around the base of the plants. Although some effect on the plants was noted, growths of pondweed up to 12 feet long were found at the end of the season, and the method was judged ineffective.

The next experiment was to study the effects of continuous treatment of growths with copper sulfate. On the basis of experience as found in the literature, the program would have been readily discouraged. The American Water Works Association manual (1) states: "With respect to copper sulfate, it may be pointed out that when that chemical is left free in water, it reacts with calcium bicarbonate to form calcium sulfate and basic copper carbonate. The basic copper carbonate may then be decomposed into copper hydrate and carbonic acid. Both the carbonate and the hydrate have very low solubilities; and in a hard water the carbonate may be almost instantly precipitated, the subsequent decomposition into the hydrate requiring a longer period.

"Insoluble copper carbonate is precipitated from the water to which it is applied—immediately in the case of most waters; more slowly, but still long before delivery, in a very soft water."

The first investigation on the effect of constant treatment of pondweed with copper sulfate was at Girard Reservoir. This is an oval-shaped reservoir of 40 acre feet capacity. It has asphalt side paving and a dirt bottom 20 feet deep, and acts as a balancing reservoir with little discharge of its storage. Pondweed growths in Girard Reservoir were always prolific. After cleaning and refilling in July, 1948, the reservoir was experimentally treated with 4.0 ppm of copper sulfate. Periodic re-treatments manitained this dosage until September when they were stopped. By the end of the year, the copper sulfate residual had dropped to 0.5 ppm. In May, 1949, heavy growths again were found in the reservoir, indicating that the copper sulfate did not have a lethal effect in destroying the growths. In a second experiment beginning in May of 1949, a residual of copper sulfate between 0.8 and 1.0 ppm was maintained until October, 1952. The initial growth was stopped and dropped to the bottom of the reservoir, where it became coated with a zoogloeal slime. No further growths developed. During this treatment of 3½ years, approximately 1000 pounds of copper sulfate were used at a cost of about $100 for the chemical.

In conjunction with the second experiment at Girard Reservoir, copper sulfate treatment on a continuous basis was started at Lower Franklin Reservoir. Lower Franklin Reservoir is a distribution reservoir of 1030 acre-feet capacity with an average depth of 32 feet, and a theoretical retention time of about six days. Pondweed growths were present in dense patches in the coves and at the shallow inlet. A copper sulfate residual between 0.8 and 1.0 ppm during the period from April to October of 1949 was successful in holding growth to less than 12 inches.

The successful application of continuous copper sulfate treatment for pondweed control is now a routine program of the Sanitary Engineering Division of the Department of Water and Power. A solution feed unit has been established at Dry Canyon Reservoir. This is a regulating reservoir through which about 75 per cent of the total supply of the City of Los Angeles passes. The flow of about 472 second feet is treated with a dosage of 0.9 to 1.0 ppm of copper

sulfate at the beginning of the growing season, reduced to 0.8 ppm about July 1, and later dropped to 0.6 ppm about the middle of August. Treatment is generally stopped early in October. The beginning of treatment is based on the finding of field biologists who keep a constant check on the biological conditions of their assigned reservoirs. Treatment at Dry Canyon Reservoir requires about one ton of copper sulfate a day at an approximate cost of $221 per day for chemicals. During the 1955 season, from May to October, 135 tons of copper sulfate were used at a total cost of about $30,000.

Since the beginning of treatment at Dry Canyon Reservoir, other benefits from the treatment have been noted in addition to the control of pondweed in the reservoir under treatment. The copper residual in the supply has been carried through a series of reservoirs having a total retention time up to 70 days. The copper in the supply was still effective in controlling pondweeds in the lower reservoirs, although there was some decrease in the concentration of the copper residual. During the period when copper was being fed at Dry Canyon Reservoir, the growth of certain algae was noticeably less in the lower reservoirs, which eliminated reservoir treatments previously required. A third effect has been the elimination of earthy, musty tastes and odors that were characteristic of the supply in the late summer.

Unfortunately, continuous copper sulfate treatment is not a panacea for aquatic weed control. It has been a solution to the principal weed problem in the Department's reservoir system, but it is noted that rushes, tules, and cattails have shown no apparent effect from the copper sulfate treatment. Furthermore, there was an increase in surface growths of blue-green algae which do not respond to copper sulfate treatment.

The copper sulfate treatment has had different effects on the fauna of the reservoir. Many carp and suckers were destroyed at Dry Canyon Reservoir at the beginning of the operation, but some large carp survived through two seasons. Bass and bluegill have survived treatment in Girard and Dry Canyon Reservoirs for several seasons, but there was a decrease in the fish population of all reservoirs receiving treated water. The evidence indicates that they will not propagate in the reservoirs under treatment. At the beginning of treatment at Dry Canyon Reservoir, a large number of paper shelled mussels (Anadonta) were also destroyed, causing a temporary taste and odor condition. It is felt that trout would not survive the copper sulfate treatment. Experience has shown that the presence of fish in the reservoirs is of little use in the control of insect life which originate at that source.

Although the loss of fish may be an important factor in the operation of certain lakes, it is of minor significance in the Department's reservoirs. Due to lack of complete treatment facilities, recreational use of the Department's facilities is restricted to the more remote reservoirs located at the source of the supply in the Sierras, in accordance with the policy of the California State Department of Public Health.

CONCLUSIONS

The water supply industry has a unique weed control problem, particularly those organizations which lack complete water treatment facilities since their product has critical limitations with respect to tastes, odors, and toxic elements. Mechanical methods, which are still the most predominant method of control, are unsatisfactory due to expense and ineffectiveness. The Department of Water and Power of the City of Los Angeles through the activities of the Sanitary Engineering Division has found a solution to the control of pondweeds in its reservoirs by the use of continuous solution feed of copper sulfate in small concentrations. Since this method is not a complete answer to the problem of weed control in domestic water supply reservoirs, it is felt that there it a great opportunity for the development of satisfactory chemical products which will meet the industry's requirements of taste, odor, toxicity, and economy.

LITERATURE CITED

1. AMERICAN WATER WORKS ASSOC. Manual of Water Quality and Treatment, Pp. 116. 1950.
2. ARNOLD, G. E. Weed growths in reservoirs and open canals. Jour. Water Works Assoc. 27:1684–1693. 1935.

Studies of Factors Affecting the Control of Chamise *(Adenostoma fasciculatum)* with Herbicides

O. A. Leonard[1]

The way in which 2,4–D (2,4–dichlorophenoxyacetic acid) is most effectively used for controlling chamise is markedly different from that normally employed on woody plants. Old plants are difficult to kill, but young regrowth following cutting or burning is especially sensitive. The purpose of the present paper is to describe what is currently known (as obtained from hand sprayed plots) about the chemical control of chamise, and some of the factors that appear to be involved. Aircraft results will be published in a separate report.

Chamise *(Adenostoma fasciculatum* H. & A.) is one of the most common shrubs of the California chaparral. It occurs in both the Coast Ranges and the foothills of the Sierra Nevada, becoming most common in Southern California. Although chamise may occur in nearly pure stands, it is generally associated with various species of manzanita *(Arctostaphylos), Ceanothus,* scrub oak *(Quercus dumosa* Nutt.), and other woody plants. There are approximately 7,000,000 acres in California upon which chamise is the most common constituent of the chaparral.

Chamise is a diffusely branched evergreen shrub which grows to a height of 2 to 10 feet. The linear leaves are fascicled and are ¼ to ½ inch long, except on sprouts and seedlings, on which they are somewhat larger and are commonly lobed. The flowering period is from February to July.

After a fire, chamise sprouts from a burl at the base of the stem producing a large number of individual sprouts, which form a dense localized canopy of foliage. The soil between the sprouting chamise plants is normally almost bare the first year after a fire, except for numerous brush seedlings including chamise which generally are present. Most of the brush seeds germinate the winter and spring following a burn and only a few will germinate later.

Chamise is capable of growing on poor soils and in areas subject to periods of one or more years of very low rainfall. It is often present on steep, rocky soils, and on soils of low fertility (such as serpentine soils) and is common in southern California; however, chamise does occur on soils of moderate depth and fertility that make a satisfactory range when cleared and seeded.

It may be desirable to control chamise for a number of reasons. Chamise covered areas are almost free of grass (Figure 1) and the canopy produced by this plant is not adequate to prevent considerable soil erosion; consequently, these areas do not have a chance to develop a better soil, since it is constantly being washed away. After a fire, erosion is even more severe and may result in considerable damage due to silting in reservoirs particularly in southern California. A grass cover is much better than chamise for holding the soil against erosion, both before and after a fire. It is not possible

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Figure 1. The effect of chamise growth following a fire on the natural establishment of resident annual grasses. The plot in the background was sprayed with 2,4–D two and one-half years after the area was burned and the picture was taken one and one-half years later. Note the absence of grass on the unsprayed plot in the foreground, where chamise is present.

to maintain a good grass cover in the face of uncontrolled chamise growth on a burned chaparral area (Figure 2), as Juhren, Pole and O'Keefe (4) have noted. Stands of annual and especially perennial grasses are more easily established following a burn where the sprouting brush plants are controlled and this has significance in

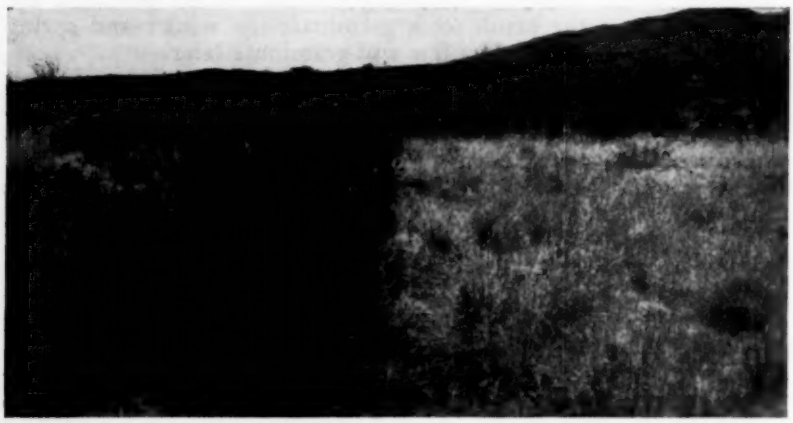

Figure 2. Effect of chamise growth on a grass stand. The plot on the right was sprayed with 2,4–D two years after the area had been burned and seeded to Hardinggrass and smilo. Photo was taken four years after the area had been burned and seeded.

the establishment of a satisfactory range. In water-deficient areas the substitution of a grass cover in the place of a brush cover reduces the total net transpiration on the area and, thus, makes more water available in springs and wells. For the above, and perhaps other reasons, control or eradication of chamise on certain areas is desirable.

The main emphasis of the work reported in this paper is on the chemical control of chamise sprouts following a burn, rather than on the control of unburned chamise, for the following reasons: (1) there has not yet been a single satisfactory kill of old unburned chamise by aircraft application, (2) where mature chamise has been killed by ground application, seeding has been unsuccessful. Recent results in this laboratory[2] indicate that chamise duff and leaves contain water soluble inhibitors which suppress the germination of grass seeds. (3) Sprouting chamise and brush seedlings are readily controlled by sprays, especially by ground equipment, and (4) grasses and legumes can be established successfully following a burn, especially by seeding in the ashes.

Although the present report is concerned mainly with chamise sprout and seedling control, other species also are involved. Fortunately, the seedlings of all species are largely controlled by spraying the first year or two after a burn; however, not all sprouting species are controlled by broadcast sprays and some must be killed using an individual plant treatment, to completely convert brush to grass. Naveh (12) in a recent report recommends that certain woody species in Israel should be controlled with sprays after burning. Evidently, spraying of brush in combination with burning should receive greater attention.

METHODS

Most of the tests to be reported were conducted on burned areas (Figure 1). It was first necessary to break off the dead stems so that the plots could be sprayed using a boom. In some cases, the chamise was crushed with a bulldozer before burning, which simplified the procedure of spraying. The sprays were applied using a knapsack sprayer which was equipped with a 3-nozzle boom and a 40-inch band was sprayed. Three 8001 Teejet tips were used on the boom, and the volume of application was approximately 20 gallons per acre; this was accomplished by using pressures of about 30 pounds and walking approximately 2 miles per hour. In actual practice, however, it was impossible to have more than approximate precision, because of uneven terrain, rocks, stumps, sticks, etc. Most of the plots were 20 feet wide and 50 feet long so as to include an adequate sample of sprouts. Plots were in duplicate unless otherwise specified.

Numerous chemicals were used in these tests over a 6 year period; they will be referred to in the tests where these were used; however,

[2]Unpublished results of Morris Ingle.

in most of the tests to be reported 2,4–D was used. Methods other than those described above will be mentioned in the separate tests.

RESULTS

Effect of spraying branch tips. Branch tips (10 per treatment) of mature chamise plants were sprayed with water emulsions containing 0.5 and 1.0 percent acid equivalent of several alkyl and heavy ether esters of 2,4–D and 2,4,5–T (2,4,5–trichlorophenoxyacetic acid) on July 19, 1950. A tag was attached to the branch at the lower end of the portion that was sprayed. Observations made over a year later indicated that the part of the branch tips that had been sprayed died in about 30 percent of the cases, but that no death occurred on the unsprayed portions of the branches. Evidently, effective herbicidal translocation downward did not occur in these tests.

Results from spraying tests indicated that chamise was most sensitive to 2,4–D during the winter and spring months, a period when soil moisture is normally high. Consequently, some branch tips of mature chamise were sprayed with water emulsions in March of 1953 using 0.5 percent acid equivalent of a low volatile ester and an emulsive acid formulation of 2,4–D. Observations 15 months later indicated that the portions of the branch tips that had been sprayed were the only parts that were dead. The new growth on the unsprayed portion of a branch directly below the sprayed part of the branch was not vigorous, suggesting some suppression due to the translocated 2,4–D; nevertheless, herbicidal quantities of 2,4–D were not translocated.

Results with radio active 2,4–D* indicated that the translocation of this compound was quite limited in the chamise plant. The 2,4–D* did not migrate into burls from applications made to stems one foot from the burls, but did migrate into the burls when applied to the basal portions of the stems. Lateral movement in the burls was not evident.

Age of sprouts. Age of the sprouts has been an important factor influencing the kill of chamise plants with 2,4–D, especially by aircraft application. More spray is deposited close to the burls on the younger (shorter) sprouts than on the older sprouts; this is important, since herbicidal translocation of 2,4–D within the chamise plant appears to be limited.

Age of the sprouts is not as important a factor influencing kill of chamise plants when the applications are made with a knapsack sprayer equipped with a spray boom, as when the applications are made by aircraft. More complete coverage of the entire plant is probably a factor favoring the kills obtained with ground equipment. Although excellent kills of chamise plants have been obtained 2 and 3 years after a burn with 2 pounds of 2,4–D per acre, some rather poor kills have, also, been encountered. It is believed that the poor kills have been associated with unsatisfactory soil moisture or plant moisture, conditions brought about by the increased transpiration of these plants resulting from the greater total leaf surface.

Moisture within the shoots from recently burned chamise is higher than in similar but older shoots, as judged by the degree of succulence. Chamise with young shoots has been readily killed with 2,4–D when sprayed at the proper time, as will be noted later.

Differences in sensitivity to 2,4–D of shoots of different ages is most marked when extremes in age are compared, as may be noted in Table 1. The recently burned chamise plants were far easier to kill with 2,4–D than were the plants that had not been burned for 12 years.

Table 1. The sensitivity of chamise plants to aqueous sprays of the isopropyl ester of 2,4–D 10 months and 12 years after a burn. Sprays were applied June 20–25, using a total volume of 40 gal/A.

2,4-D lbs/A	Chamise plant kill	
	10 months after a burn—pct.	12 years after a burn—pct.
2	10	0
4	37	0
8	98	12

Effect of age on sensitivity of new sprouts. It was thought that after a burn chamise plants might be killed by spraying before the sprouts had appeared above the surface of the soil. In the first experiment, chamise burned in September was sprayed in November when only 10 percent of the burls had sprouts that were visible. The rate of application was 8 pounds of 2,4–D per acre. Only a few of the chamise plants were killed by this treatment.

In a later test, chamise was burned in August and sprays were applied the following spring on 4 different dates. At the time of spraying the height of the sprouts was measured on the different burls. Data from this experiment are shown in Table 2. The treatment consisted of 2 pounds of 2,4–D (propylene glycol butyl ether ester) applied in 1 gallon Diesel oil and 18½ gallons of water per acre, except on the last 3 dates when 38½ gallons of water were used. The results show that it is possible to spray too soon after a burn for a good kill. Sprouts did not develop simultaneously on all sides of a burl and it was necessary to have most of the potential sprouting sites developed into sprouts at the time of spraying. When this was accomplished, the sprayed sprouts all died and most of the new sprouts developing later, died within a few months, evidently from the translocated 2,4–D present in the burl.

It is possible to delay spraying too long for a good kill to result; however, the poorer kill is related to a lower soil moisture at the season of application. Later in the year when the rainy season has started, the chamise plants again become sensitive to 2,4–D; however, they probably never again will be quite as sensitive as they were on the June 4 date of application. This is especially true for aircraft application, but is true to some extent for applications made with a knapsack sprayer equipped with a boom. Seedlings were controlled, except during the summer period when moisture was low.

Table 2. Kill of chamise plants by 2,4–D sprays applied at different times of the year, following an August burn made the previous year.

Date treated	Soil moisture	Chemical kill—pct.[1]		Pct. burls with sprouts of maximum heights in inches				
		Sprouts	Seedlings	No sprouts	0–3	3–6	6–9	9–12
Aug. 4	high	57±4[2]	100	32	63	5	0	0
Apr. 16	high	72±4	100	27	12	32	29	0
May 12	high	85±2	100	24	4	22	34	16
June 4	medium	99±0	100	22	2	19	36	21
Aug. 10	low	23±5	80	—	—	—	—	—
Nov. 10	medium	66±5	100	—	—	—	—	—

[1]Chemical kill is based on the plants that were evidently killed as a result of spraying. Kill was determined eighteen months after the last treatment was applied. Fire kill (assumed to be 22 percent) was not included in this calculation.
[2]Average and difference in kill between duplicate plots.

Effect of season of application on 2-year-old sprouts. The purpose of the following study was to determine the effect of season of application on the sensitivity of 2-year-old sprouts to 2,4–D. The brush was crushed by a bulldozer in the summer of 1950 and burned in October. Immediately after burning, the area was seeded by airplane to Hardinggrass *(Phalaris tuberosa),* smilo *(Oryzopsis miliacea),* and tall fescue *(Festuca arundinacea).* The most important effect of the seeded grasses was to compete successfully against many of the brush seedlings.

Plots having dimensions of 20 by 50 feet were laid off and treated in duplicate on different dates during 1952. Data on these are presented in Table 3. Marked changes in sensitivity of the chamise plant to 2,4–D are evident; these appear to be related mainly to changes in soil moisture. Chamise plants were sensitive to 2,4–D in February before there was any appreciable shoot growth. Shoot growth was most rapid between April 15 and June 1, after which growth was reduced as the soil moisture became depleted. Coupled with the reduction in soil moisture was a marked decrease in sensitivity of the chamise plant to the 2,4–D sprays. Although the data reported were obtained 18 months after the last treatment was applied, readings 3 years after treatment were still about the same.

Aircraft sprays on 2-year-old chamise sprouts have resulted in kills ranging from 0 to 50 percent, using 2 pounds of 2,4–D per acre.

Table 3. Effect of date of application on the kill of 2-year-old chamise sprouts with 2,4–D (PGBE ester). Two pounds of 2,4–D were used per acre in 2 gallons of Diesel oil and 37½ gallons water. Readings were obtained 18 months after the last date of application.

Date applied	Shoot growth	Soil moisture	Plant kill—pct.	
			Sprouts	Seedlings
Feb. 25	none	high	90±2[1]	100
Mar. 28	slight	high	88±2	100
Apr. 17	active	high	100	100
May 16	active	medium	78±4	99
July 14	slight	low	5±1	slight
Sept. 18	slight	low	0	slight

[1]Average and difference in kill between duplicate plots.

Effect of formulation. Early in these studies it was found that there were marked differences in the effectiveness of different formulations of 2,4–D and 2,4,5–T for controlling chamise sprouts. The isopropyl ester repeatedly failed to be as active against chamise as were the butoxy ethanol esters and the mixed propylene glycol butyl ether esters (PGBE ester) (7). The polyethylene glycol 200 and 600 mono esters usually gave good control of chamise sprouts when the applications were made with a knapsack sprayer during periods when chamise was susceptible; however, these esters failed to give more than a slight kill when applied by aircraft.

Some data (recorded 2 years after treatment) showing the effectiveness of ester, amine and suspended acid formulations are presented in Table 4. The esters were considerably superior to both the amine and suspended acid formulations on chamise. The effectiveness of esters applied as oil emulsion is demonstrated in this table.

Table 4. The effect of 2,4–D and 2,4,5–T ester (PGBE), amine, and suspended acid formulations on the kill of 2-year-old chamise sprouts. Applications were made in November using 40 gallons of total spray per acre.

Chemical formulation	Diluent	Pounds acid per acre	Sprout kill—pct.	
			2,4-D	2,4,5-T
Ester	Water	2	9	7
	Water	4	19	29
	Water	8	72	70
	Water	16	96	98
	25 pct. Diesel/water emulsion	2	66	44
Amine	Water	2	0	0
	Water	4	0	0
	Water	8	12	7
	Water	16	61	12
Acid, suspended	25 pct. Diesel/water emulsion	2	0	0
		4	0	0
		8	21	0
		16	64	47

Effect of chemical. The effects of 2,4–D and 2,4,5–T have been compared in many different tests on sprouting chamise. With hand sprayed plots, there often has been no big difference between the two chemicals in their effectiveness; however, it has been noted that under conditions when chamise is in an especially sensitive state, 2,4–D is considerably superior to 2,4,5–T (Table 5). The effectiveness of 2,4–D appears to vary considerably more than that of 2,4,5–T and at times there appears to be an advantage to using a mixture of the 2 chemicals; this appears to be especially true on older bushes, and when soil moisture is not optimum.

MCPA (2–methyl–4–chlorophenoxyacetic acid) was must less effective than either 2,4–D or 2,4,5–T on chamise. The ester and amine forms of 2–(2,4–DP)[1] and 2–(2,4,5–TP)[2] were compared with 2,4–D and 2,4,5–T in several tests, with comparatively poor kills

[1]2(2,4–dichlorophenoxy)propionic acid
[2]2(2,4,5–trichlorophenoxy)propionic acid

Table 5. Effect of 2,4–D and 2,4,5–T esters and combinations on the control of chamise sprouts. Applications were made using 2 pounds of acid equivalent in 2 gallons of a non-toxic oil and enough water to make 40 gallons solution per acre. Applied in April on 1½-year-old sprouts.

Formulation	Chamise sprout kill—pct.		
	2,4-D	2,4,5-T	2,4-D+2,4,5-T
Butoxy ethanol ester	100	52	97
Propylene glycol butyl ether ester	99	50	90
Polyethylene glycol mono-ester[1]	100	13	97

[1]2,4-D—P.G. 200 ester
2,4,5-T—P.G. 300 ester

resulting; however, by adjusting the concentration or poundage of application, either of these chemicals can be used to kill chamise.

The following chemicals were relatively ineffective on chamise: amino triazole at 8 lb/A on one-year-old sprouts, maleic hydrazide at 4 lb/A on 1½-year-old sprouts, sodium trichloroacetate at 40 lb/A on 2-year-old sprouts and dichloral urea at 20 lb/A on 2-year-old sprouts. CMU (3–(*p*–chlorophenyl)–1,1–dimethyl urea) was effective at 40 pounds per acre in killing all of the chamise sprouts, but the area has remained free of grass for more than 3 years.

Influence of oil and type of oil. The addition of some oil to the spray mixture has aided in killing chamise sprouts with 2,4–D but the benefit has been variable, being greatest in the summer and fall. Results are not presented here (although an example may be found in Table 4) but some earlier data have already been published (6, 7).

Since it was amply demonstrated that some oil in the spray mixture had a pronounced influence on the effectiveness of 2,4–D on the chamise plant, it was necessary to determine the properties of the oil that would be most desirable. In the first experiment (Table 6) the spray mixture consisted of (for 1 acre) 2 pounds of 2,4–D, 2 gallons of oil, enough water to make 40 gallons. Plant kill decreased as the viscosity of the oil increased. There is no suggestion that the effectiveness of 2,4–D was lessened by the use of Diesel oil, even though its U.R. (unsulfonatable residue) was probably lower. One factor that may have influenced the kill was the poorer emulsification obtained with the high viscosity and high U.R. oils.

Table 6. Effect of different oils on the effectiveness of 2,4–D (PGBE ester) in killing chamise plants having 1½-year-old sprouts.[1]

Oil used	Viscosity SUS at 100° F	Distillation characteristics	UR—pct.	Plant kill—pct.
Diesel oil	38	10% at 436°F 90% at 630°F	—	95
Shell Mineral Seal	46	Start at 497°F End at 650°F	90	93
Shell Tank Mix no. 1	61	65–100% at 636°F	90	84
Shell Tank Mix no. 5	101	13–20% at 636°F	94	73

[1]Oils supplied by the Shell Agricultural Laboratory.

The results in this table suggest that the oils should not have a viscosity higher than 46 (Shell Mineral Seal) for best kills.

The next experiment was conducted to study oils having lower viscosities than those used in the first test. As in the first experiment, the rate of application of 2,4–D (PGBE ester) was 2 pounds per acre. The quantity of oil used was decreased to 1 gallon with enough water added to make the spray application equal to 20 gallons per acre. The results from this test (Table 7) indicate that the greatest sprout kill resulted from the use of an oil having a viscosity of 40. Mineral spirits was by far the least effective of the oils studied. Considering the results from the 2 experiments, oils used with 2,4–D for controlling chamise should have a viscosity between 36 and 46 for best results; oils outside of this viscosity range should be avoided.

Table 7. Effect of different oils on the effectiveness of 2,4–D (PGBE ester) in killing chamise plants having 4-year-old sprouts.[1]

Oil used	UR pct.	Viscosity SUS at 100°F	Boiling range °F	Plant kill pct.
Mineral spirits	99	—	347–394	48 ±5[2]
Bayol D	99	32	400–505	76 ±4
RDA 182	95	36	408–609	82 ±4
Mentor 28	91	40	420–655	87 ±3
Diesel	—	38	———	83 ±3

[1]Oils supplied by the Esso Laboratories.
[2]Average and difference between duplicate plots.

Effect of burning, spraying, and reburning. Three-year old chamise sprouts were sprayed with PGBE esters of 2,4–D, 2,4,5–T, 2–(2,4–DP), and 2–(2,4,5–TP) in April. A wild-fire swept through the plots in August which burned the plot area but died out shortly beyond its boundaries. Most of the plots were burned completely, especially those that had sprays which were sufficiently effective to kill most of the chamise sprouts (the 4 and 8 pound per acre rates of all chemicals and the 2 pound rate of 2,4,5–T). The plots that received the 2 pound per acre applications, especially with 2–(2,4–DP) and 2–(2,4,5–TP, had many chamise plants that had already developed succulent new shoots at the time of the wild-fire. These plots did not burn as completely as did those that had received a greater quantity of chemical per acre.

The results in Table 8 (recorded 18 months after spraying) indicate that burning was highly effective in bringing about a kill of the sprayed plants. The reburn did not result in the death of any of the chamise plants which had not been sprayed; however, certain differences did exist between the sprayed and unsprayed plots. The fire was probably hotter on the sprayed plots than on the unsprayed plots because shoots had been desiccated by the sprays; in addition to this, dormancy of the buds had been broken after the spraying and these buds had developed into shoots which were killed by the fire. The fuel supplied by grass did not contribute much to the burn, since there was only about 100 pounds of dry grass per acre on the plots.

Table 8. Kill of 3-year-old chamise sprouts as a result of spraying (in April) and burning (in August).

Chemical used	Acid equivalent per acre—lbs.	Chamise plant kill—pct.	
		Burned after spraying	Not burned
2,4-D	2	93	33
	4	100	—
2-(2,4-DP)	2	55	10
	4	95	—
2-(2,4,5-TP)	2	82	10
	4	89	—
Untreated	—	0	0

In other experiments, it has been found that burning chamise the next year after spraying has been completely ineffective in improving the kill of chamise over burning alone.

The effect of burning the same year as spraying appears (1) to have made a good burn possible and (2) to have resulted in a high degree of chamise plant kill with 2 pounds of 2,4–D per acre and a fair kill with 2 pounds of the propionic acid compounds.

Discussion and Conclusions

Chemicals such as 2,4–D must be absorbed and translocated in order to be effective in the control of perennial plants. Leonard and Crafts (11) indicate that the speed with which 2,4–D is moved is influenced by the season of application but that in most cases rate of movement is not critical in determining effectiveness. Quantitatively, translocation of 2,4–D varies from species to species. Among the species studied the greatest longitudinal movement occurred in willow *(Salix* sp.) and coyote brush *(Baccharis pilularis),* and the least in interior live oak *(Quercus wislizenii).* The first two species are easily killed with 2,4–D and the latter species is killed with difficulty. The distribution of radio-activity suggests that 2,4–D is being tied up in the live oak phloem to a much greater extent than in willow and coyote brush. Recent data by Fang, Johnson and Butts (3) show that some of the 2,4–D applied to bean plants becomes associated with a protein fraction. Brian and Rideal (1) using a Langmuir trough technique consider that the differences in sensitivity of broadleafs and grasses to MCPA is due to the fact that MCPA becomes chemically bound with materials in grasses and, therefore, is not physiologically active.

Although chamise appears to be extremely sensitive to 2,4–D under some conditions, translocation appears to be limited. The 2,4–D is probably quickly bound to some plant constituents and is not free to move very far from the point of application. The extreme seasonal changes in sensitivity suggest that the binding also varies with the season being most marked when the plants are structurally and chemically well differentiated. Seasonal changes in sensitivity and nutritional balance are undoubtedly related to other factors, such as maturation of tissues.

Young seedlings or young sprouts from recently cut or burned plants are quite easily killed with 2,4–D (8). The leaves are much larger than the leaves on older sprouts and seedlings and seem to absorb and move more of the applied 2,4–D. The new shoots all develop from a restricted vertical portion of the burl; thus, vertical translocation does not have to be extensive in order to kill all of the tissues which might produce sprouts. The main problem appears to be associated with limited lateral translocation of 2,4–D in the burls.

On shoots that are short, the sprays are of necessity applied to leaves which are close to the attachment of the stems to the burls; this favors the movement of the applied materials into the burls, and may result in a high percentage of the plants being killed. This happens when some sprouts are present from all of the potential sprouting areas on the burls at the time of spraying and when there is sufficient soil moisture for active growth. Under these conditions, new shoots which develop after spraying, may die within a few months.

The time when spraying is done in the spring, following a fall burn, is important in determining plant kill, and appears to be related to some of the factors already discussed. Sprouts do not develop from all areas of a burl simultaneously, so when sprays are applied too early, sprouts emerging later from some other area of the burl may survive, since the lateral movement of 2,4–D appears to be limited. After the burls have developed sprouts from all of the areas which might sprout, the next factor that dominates plant kill with 2,4–D is soil moisture. As soil moisture becomes reduced, the plants become less sensitive to 2,4–D. The rate at which water is lost from the soil is influenced by the total quantity of vegetation present on the site.

The reason that it is possible to kill chamise plants having young, actively growing sprouts appears to be that chamise leaves are not rapidly injured by the contact action of 2,4–D. This may allow the plant ample time to shift the direction of movement downward, after the physiology of the shoots has been altered sufficiently by the treatment. Furthermore altered biochemistry in the shoots brought about by the 2,4–D may, through catabolic reactions, release the "bound" 2,4–D for translocation into the burls. With plants having leaves that are quickly injured by the contact action of 2,4–D, such as poison oak, spraying the very young shoots has not been satisfactory.

On chamise plants having sprouts that are 2 years old and older, the major factor influencing kill with 2,4–D is soil moisture. Chamise is normally sensitive throughout the winter and spring months, when rainfall is plentiful. It becomes increasingly difficult to kill with the progress of summer. With the advent of the fall rains, the plants become sensitive again and this is not related to appreciable shoot growth. Similar observations on a marked increase in sensitivity of live oak and blue oak to 2,4–D in the late fall has already been reported (2), (9), (10).

The addition of some oil to the spray mixture improves the kill (6), (7), (8); however, the importance of oil varies with the season, being most essential during dry periods. The type of oil most suited is of a paraffin type, but the small amount of aromatics normally present in Diesel oil does not appear to be detrimental. Oils having low viscosities, such as mineral spirits, appear to be less satisfactory than oils that are somewhat more viscous. Leonard and Harris (5) have shown that paraffin hydrocarbons decrease in plant toxocity as the number of carbon atoms per molecule is increased from ten to fourteen, but the toxicity of the latter (tetradecane) is still appreciable, and corresponds somewhat to kerosene (viscosity 32). Perhaps, it is necessary to have oils of greater viscosity than kerosene in order to reduce the injurious effect of the oil itself on the plant tissues. In these studies, an oil having a viscosity of about 40 appeared to be most satisfactory as an additive to esters of 2,4–D. Limited spreading of the more viscous oils probably reduces their effectiveness. Evidently, the best oil represents a compromise between the injury produced by the oil itself and viscosity as this relates to spreading and penetration.

At times when oil is most essential as an additive to hormone sprays for killing chamise, 2,4,5–T shows some advantage over 2,4–D. It is considered that 2,4,5–T penetrates bark better than 2,4–D and oil helps to increase the penetration of both chemicals through bark. When the major entry of chemical is through the leaves, the favored chemical is considered to be 2,4–D.

Burning chamise within the year of spraying appears to result in a marked increase in the percentage of the plants killed, especially when the sprays by themselves are not very effective (such as the 2 pound per acre rates of 2,4–D, 2–(2,4–DP), and 2–(2,4,5–TP) in this experiment). Burning killed the new sprouts that developed after the older sprouts were killed by the spray. The combination of spraying and burning was highly effective in killing chamise when both operations were performed within a few months of each other; however, the beneficial effect of the combination has not been observed when the burning has been delayed for a year or more after spraying. Burning alone does not appear to be effective in killing many chamise plants, except when combined with heavy browsing by deer or other animals.

SUMMARY

1. Branch tips of chamise failed to die beyond the point where they were sprayed. These findings indicate that the translocation of herbicidal quantities of 2,4–D and 2,4,5–T is limited.

2. Chamise plants were readily killed with 2,4–D by spraying the young sprouts in the spring, following a fall burn. Spraying too soon before all of the potential sprouting portions of the burl had developed sprouts, resulted in many plants not being killed. Delaying the spraying until after the soil moisture was greately reduced, also, resulted in a poor kill.

3. Soil moisture appeared to be the main factor influencing the

kill of two-year-old sprouts with 2,4–D, providing the plants were well covered by the spray. Poor coverage, especially around the basal portions of the stems, is considered to be the main reason for the lack of success in killing 2-year-old and older chamise by aircraft application. Excellent kills have generally been obtained using a knapsack sprayer equipped with a boom, with application rates of 20 to 40 gallons per acre.

4. Some oil added to the spray mixture generally markedly improves the kill. The type of oil that is best appears to be a high U.R. oil that has a viscosity of about 40. The aromatics present in Diesel oil do not appear to be appreciably detrimental.

5. When chamise is actively growing, 2,4–D is the most effective herbicide; when soil moisture is low, 2,4,5–T appears to be slightly superior to 2,4–D on chamise. The propylene glycol butyl ether ester and the butoxy ethanol ester were by far more effective than the isopropyl ester, the amines, and acid formulations on chamise.

6. Seedlings of chamise are quite sensitive to 2,4–D and have been completely eliminated by a single broadcast application of 2 pounds per acre of 2,4–D, applied either the first or the second year after a burn. Seedlings of all brush species have been killed by the above application made the first year after a burn. Some seedlings emerge after the spraying and these may survive.

7. A reburn in August following a chemical treatment in April resulted in a high degree of kill of chamise plants. The chemicals 2–(2,4–DP) and 2–(2,4,5–TP) were relatively ineffective in killing chamise, except when combined with the reburn. Reburns made two or more years after spraying have not been effective in appreciably increasing the plant kill over spraying alone. The spraying dried the plants enough to make a reburn possible on an area where grass was sparse.

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LITERATURE CITED

1. BRIAN, R., and RIDEAL, E. K. On the action of plant growth regulators. Biochem. & Biophys. Acta 9:1–18. 1952.
2. EMRICK, WALTER E., and LEONARD, OLIVER A. Delayed kill of interior live oak by fall treatment with 2,4–D and 2,4,5–T. Jour. Range Management 7:75–76. 1954.
3. FANG, S. C., JOHNSON, R. H., and BUTTS, J. S. Absorption, translocation, and metabolism of radioactive 2,4–D, 2,4,5–T, o–chlorophenoxyacetic acid and 2,4,6–T in bean plants. Abst. Amer. Soc. Plant Phys., West Sec., Pasadena, Calif. 1955.
4. JUHREN, G., POLE, R., and O'KEEFE, J. Conversion of brush to grass on a burned chaparral area. Jour. Forestry 53:348–351. 1955.
5. LEONARD, O. A., and HARRIS, V. C. The effect of aliphatic hydrocarbons on the hypocotyls of cotton and soybeans and on the shoots of nutgrass, Johnsongrass and other weeds by the directional spray technique. Weeds 1:256–273. 1952.

6. LEONARD, O. A. Results of a test on the chemical control of chamise sprouts *(Adenostoma fasciculatum)* and seedlings. Res. Progress Report, Western Weed Control Conf. p. 51–53. 1952.
7. ———. High volume application of herbicides to sprouting and seedling chamise. Proc. Calif. Weed Conf. pp. 43–53. 1953.
8. ———, and CARLSON, C. E. Chemical brush control techniques on California range lands. Calif. State Div. Forestry Report, pp. 1–12. 1955.
9. ———. Some observations on new chemicals for woody plant control and some factors influencing success with cut-surface treatments for killing trees. Proc. Calif. Weed Conf. pp. 94–99. 1955.
10. ———. Effect on blue oak *(Quercus douglasii)* of 2,4–D and 2,4,5–T concentrates applied to cuts in trunks. Jour. Range Management 9:15–19. 1956.
11. ———, and CRAFTS, A. S. Studies on the uptake and distribution of radioactive 2,4–D by brush species. Hilgardia (in press).
12. NAVEH, S. Trials for the improvement of natural hill pasture in Israel by selective weed and brush control. Progress Report 1950–54. Agric. Res. Sta., Rehovot Series 1954, No. 81. p. 1–6. 1955.

The Crop Toxicity Period of CMU in a Sandy Clay Loam Soil[1]

L. L. Danielson[2]

The present report marks the completion of a 24-month study. The early phases have been described in brief in a progress report (3). Data contained in the earlier report are included in the present discussion to make the entire experimental record available as a unit.

The experimental study described here was organized to provide basic information on the effect of various rates of application of CMU (3–(*p*–chlorophenyl)–1,1–dimethyl urea) on certain vegetable crop plants and to determine the duration of the phytotoxic period characteristic of these rates in a representative Virginia soil type.

Results given here also demonstrate a very effective method of studying herbicidal activity by the use of drainage tile set on end in the field. This method affords the advantages of observation of effects under known field climatic conditions and avoids certain disadvantages of field trials such as horizontal treatment displacement due to rainfall, and those due to soil variations in texture, organic matter content, and contour.

Review of Literature

Entrance of CMU through the roots of plants was demonstrated by Bucha and Todd (1) and the resulting toxicity symptoms were described. Research reported from various sections of the United States (2, 10, 11, 12, 13, 14) has shown quite clearly that inactivation of CMU is most rapid in soils of high clay and organic matter content. It has been demonstrated (3, 5, 7, 9) that rainfall or irrigation does not appreciably affect the movement of CMU down through the soil. Studies of the effect of temperature level on persistance of CMU in the soil (7, 11) have indicated that the rate of dissipation increases with temperature. It has been suggested (4, 6, 9) that tilth and granular structure may affect initial penetration of CMU into the soil and its subsequent activity with respect to both crops and weeds. A comprehensive study (8) of factors affecting the toxicity period of CMU in the soil and the mechanisms involved in detoxification indicate that soil residue problems should not result from small annual applications of this chemical. Photo decomposition is also suggested as an important factor in detoxification of CMU as a result of this study.

These investigations form a background for consideration of the results obtained in the present study where basic and practical interests were combined.

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[1]Contribution from the Plant Physiology Department, Virginia Truck Exp. Sta., Norfolk, Virginia. Paper No. 122, Journal Series, approved for publication July 28, 1955.

[2]Plant Physiologist.

EXPERIMENTAL PROCEDURE

Preparation of Experimental Containers. Initial preparations for the experiment were made in the following manner. Glazed drainage tiles 30 inches long and 15 inches in diameter were utilized for the experiment. These had been up-ended and set into holes in a field plot so that the upper ends were 3 to 4 inches above the surrounding soil as shown in Figure 1. These were filled with a uniform mixture of soil by screening sufficient soil at one time to fill all of the tiles. The soil was packed, with the exception of the top 6 inches, as it was filled into each tile. The tiles were filled to approximately 4 inches from the top. A sandy, clay loam soil having a pH of 5.6 and classified as a Craven (Mattapex) soil was used. This is a moderately well-drained soil with silt and clay predominating and containing some gravel. Organic matter content was 2.21 percent.

Figure 1. Experimental area showing placement and general arrangement of the tiles.

Method and Rate of CMU Application. In June, 1952, at the beginning of the experiment, rates of 0.5, 1, 2, 3, 4, 5, 10, 15, 20, 25, and 50 pounds of actual chemical per acre were applied by suspending the amount for each tile in 1 liter of water and distributing it over the surface of the soil. This was allowed to dry for one week and the top 5 inches of soil in each tile was then thoroughly mixed to distribute the chemical evenly in this layer. In 1953 pre-emergence applications of 0.5 to 5 pounds per acre were made as a surface application in 100 grams of 300 mesh pyrophyllite per tile in the respective tiles treated with these rates in 1952. Treatments of the series from 10 to 50 pounds were not repeated. In 1954 pre-emergence applications of 0.5 to 5 pounds per acre were made as a surface spray application in one pint of water per tile in the respective tiles treated with these rates in 1952 and 1953. Treatments of the series from 10 to 50 pounds were not repeated.

Method of Planting. 10 seeds each of sweet corn and snap beans and 25 of spinach and kale were planted at a uniform depth of one inch at monthly intervals for 3 months following treatment in 1952. Plantings made in 1953 and 1954 were limited to sweet corn and snap beans. The soil was thoroughly mixed to a depth of 5 inches immediately before each planting to simulate deep disking or shal-

low plowing. Aristogold sweet corn, Top Crop snap beans, Old Dominion Blight Resistant spinach, and Vates Dwarf Blue Scotch kale were used. A randomized block design of 5 replications irrigated and 5 replications unirrigated was used. Irrigated plots received one inch of water per week throughout the experimental period from June to October in 1952. In 1953 and 1954, irrigation was limited to the growing period of the crops used.

Climatic Data. Rainfall was recorded in the experimental area for the 24-month period. Thermographic records of air temperature were made for the entire period and degree hours above 0° F. were calculated. The temperature record is given in detail in terms of degree-hours in order to present an accurate, cumulative record of the temperature factor. Mean temperatures from daily extremes do not provide this information on an accurate basis. Since temperature is an extremely important factor affecting rate of chemical reactions, isolated field experiments involving physical and chemical reactions can only be coordinated if the most accurate method of reporting climatic data is used in every case. It is the opinion of this author that this may be one of the important means of explaining the apparent contradictions which occur in data from one season to another or one part of the country to another. The climatological records are presented in Table 1.

Table 1. Climatological records for 1952, 1953 and 1954.

Treatment and planting dates	Cumulative rainfall—inches	Cumulative irrigation—inches	Cumulative temperature—degree hrs./1000
1952, June 6	0	0	0
1952, July 11	3.23	3	66.8
1952, August 12	7.43	7	128.6
1952, September 11	10.58	11	184.0
1953, June 23	45.68	15	555.1
1953, July 16	48.82	19	597.5
1954, June 10	92.21	19	1017.0
1954, July 9	97.45	23	1069.2

Method of Determining Plant Response to Treatment. Emergence stand counts were followed by final stand counts when plants were rem ved from the tiles approximately 4 weeks after planting. Plants were severed at the ground line at this time for fresh weight determinations on the tops. The data presented here show the effect of treatment with CMU on the early vegetative growth of the crops used. Treatment dates were June 6–9, 1952; June 23, 1953, and June 10, 1954. Planting dates were July 11, 1952; August 12, 1952; September 11, 1952; June 23, 1953, and June 10, 1954. Harvest dates were August 5, 1952; September 8, 1952; October 9, 1952; July 16, 1953, and July 9, 1954.

RESULTS

1952—Results of the trials using sweet corn, snap beans, spinach and kale in 1952 are presented in Tables 2, 3, 4 and 5. Rates of up

to 5 pounds per acre worked into the top 5 inches of soil were dissipated sufficiently in 3 months to allow normal early vegetative growth of these crops. Snap beans appeared to be more tolerant of CMU than did sweet corn. Spinach appeared to have a greater tolerance of CMU than kale. Similar applications of 10 to 50 pounds were still quite toxic after 3 months.

On the basis of these observations, the presentation and discussion of results are divided into 2 parts considering rates of up to 5 pounds of CMU per acre as short term treatments, Tables 2, 3, and 4, and rates of 10 pounds and above as long term treatments, Table 5.

1953—Results of the 1953 low rate application trials planted in June are given in Tables 2 and 3. As indicated in the experimental procedure, the acre rates up to 5 pounds were repeated immediately after planting at this time. These applications, made in dry form in pyrophyllite and allowed to remain on the soil surface, produced injury in both the corn and beans at rates above 0.5 pound. Severe injury was noted in the rates from 2 to 5 pounds in these crops.

Table 2. Effect of low rates of application of CMU on emergence and growth of sweet corn.

CMU lb/A[1]	1952			1953	1954
	Elapsed time—treatment to planting			Pre-emergence—dry application	Pre-emergence—spray application
	1 mo.	2 mo.	3 mo.		
	Av. stand per tile				
0	8.0	8.8	8.5	9.0	9.2
0 + W	7.6	9.8	9.6	9.2	8.8
0.5	8.2	8.6	8.4	8.0	9.4
0.5 + W	9.0	9.8	9.6	8.8	10.0
1	6.6	9.6	8.6	8.4	9.6
1 + W	8.4	9.8	8.8	9.4	9.8
2	7.8	9.4	8.8	8.6	9.4
2 + W	8.4	9.4	8.6	7.6	9.4
3	4.4	9.6	9.4	3.6	9.2
3 + W	7.6	8.4	9.4	6.0	9.2
4	1.8	8.4	8.0	1.6	9.6
4 + W	7.0	9.6	9.4	3.0	9.6
5	3.4	9.0	9.0	3.6	9.4
5 + W	3.4	9.0	9.6	4.6	10.0
L.S.D. 5%	1.8	1.9	1.8	3.4	N.S.
1%	2.4	2.5	2.4	2.6	N.S.
	Av. fresh wt. of tops—gms.				
0	26.5	19.1	4.7	28.1	24.5
0 + W	33.9	17.7	5.8	27.7	26.0
0.5	26.9	21.6	4.8	24.9	28.0
0.5 + W	41.5	17.6	6.2	36.9	31.9
1	20.1	17.3	3.9	21.8	19.9
1 + W	24.9	17.9	6.4	21.5	29.8
2	22.8	15.4	4.5	10.7	20.3
2 + W	28.4	18.1	6.2	9.0	27.4
3	19.0	16.2	5.7	3.5	25.3
3 + W	17.6	17.6	6.4	6.4	23.1
4	2.8	7.3	5.5	2.6	15.1
4 + W	8.4	12.5	7.1	5.7	21.5
5	6.8	8.5	5.7	1.8	15.8
5 + W	5.5	5.7	4.2	3.9	19.2
L.S.D. 5%	9.7	5.2	1.4	6.1	6.4
1%	12.7	6.9	1.9	4.6	8.4

[1] "W" indicates irrigation in addition to rainfall.

The initial applications of acre rates of 10 to 20 pounds, Table 5, mixed into the top 5 inches of soil in 1952 were dissipated after 12 months as indicated by growth of sweet corn and snap beans planted in June 1953. The initial applications of 25 to 50 pounds per acre were still very toxic after 12 months.

1954—Results of the 1954 trials planted in June are given in Tables 2, 3, and 5. In these plantings, the acre rates of 0.5 to 5 pounds were applied immediately after planting as a spray which was allowed to remain on the soil surface. The tiles treated in 1952 with rates of 10 to 50 pounds were planted with sweet corn and snap beans but were not treated again at this time in order to determine the residual effect of the original treatment after 24 months.

Table 3. Effect of low rates of application of CMU on emergence and growth of snap beans.

CMU lb/A[1]	1952			1953	1954
	Elapsed time—treatment to planting			Pre-emergence—dry application	Pre-emergence—spray application
	1 mo.	2 mo.	3 mo.		
	Av. stand per tile				
0	5.8	7.8	7.0	8.0	7.2
0 + W	6.2	8.0	7.6	8.8	9.2
0.5	5.8	7.8	7.4	8.0	8.0
0.5 + W	6.4	8.4	8.6	8.6	9.6
1	4.0	8.4	7.0	7.6	9.0
1 + W	7.6	7.8	9.0	8.4	9.6
2	5.2	7.0	6.4	6.0	7.8
2 + W	7.2	8.4	6.6	6.6	9.0
3	4.0	8.4	8.8	2.0	9.4
3 + W	6.2	7.6	8.8	2.6	9.2
4	4.6	8.0	7.6	1.2	9.0
4 + W	5.4	8.2	7.2	2.8	8.2
5	5.0	7.0	7.8	0.8	9.0
5 + W	3.6	7.8	7.2	0.6	7.6
L.S.D. 5%	2.2	2.1	4.9	3.7	N.S.
1%	3.0	2.8	6.5	2.8	N.S.
	Av. fresh wt. of tops—gms.				
0	4.3	14.1	7.6	13.7	13.6
0 + W	6.4	12.0	6.8	11.5	12.7
0.5	4.4	10.3	8.8	14.6	13.8
0.5 + W	5.6	7.9	8.8	13.4	14.9
1	2.6	11.2	6.9	9.1	9.8
1 + W	7.3	11.3	8.3	22.8	14.5
2	5.0	10.2	7.9	6.2	11.9
2 + W	7.2	12.3	9.2	15.7	15.7
3	3.3	11.5	9.0	8.0	11.9
3 + W	6.7	10.4	9.1	5.6	12.2
4	3.1	9.0	9.0	6.2	9.3
4 + W	5.1	12.9	10.9	4.5	11.6
5	4.0	7.0	8.2	0.7	9.1
5 + W	5.2	8.1	6.3	3.7	11.4
L.S.D. 5%	2.2	3.4	2.4	2.6	3.2
1%	2.9	4.6	3.1	2.0	4.2

[1] "W" indicates irrigation in addition to rainfall.

Table 4. Effect of low rates of application of CMU on emergence and growth of kale and spinach in 1952 trials.

CMU lb/A[1]	Kale		Spinach	
	Elapsed time—treatment to planting		Elapsed time—treatment to planting	
	2 mo.	3 mo.	2 mo.	3 mo.
	Av. stand per tile			
0	10.0	11.8	6.8	8.2
0 + W	14.4	10.2	5.8	7.0
0.5	11.4	11.4	7.4	5.4
0.5 + W	10.0	9.2	4.2	7.2
1	12.2	8.8	6.8	9.6
1 + W	12.6	7.8	6.8	12.6
2	7.0	13.0	4.6	12.6
2 + W	10.2	9.0	4.8	6.4
3	4.4	6.2	4.4	11.0
3 + W	5.2	6.8	2.8	7.4
4	1.2	4.8	0.6	12.6
4 + W	3.0	8.4	1.4	4.4
5	0.0	4.2	1.8	13.4
5 + W	0.6	6.4	1.2	12.4
L.S.D. 5%	4.8	5.7	3.2	6.2
1%	6.3	7.6	4.2	8.2
	Av. fresh wt. of tops—gms.			
0	0.79	1.59	0.48	4.97
0 + W	0.69	1.18	0.40	8.92
0.5	1.60	1.36	0.64	2.59
0.5 + W	0.94	2.31	0.68	6.75
1	0.54	1.07	0.84	8.59
1 + W	0.55	1.34	0.56	11.65
2	0.23	0.87	0.39	4.53
2 + W	0.94	1.57	0.68	13.57
3	0.08	1.27	0.32	5.62
3 + W	0.11	0.42	0.19	6.86
4	0.02	0.39	0.23	3.38
4 + W	0.12	1.03	0.03	5.64
5	0	0.42	0.01	3.12
5 + W	0.01	0.58	0.04	5.43
L.S.D. 5%	0.42	0.77	0.28	6.3
1%	0.55	1.03	0.37	8.3

[1] "W" indicates irrigation in addition to rainfall.

The applications of 0.5 to 5 pounds in spray form immediately after planting in 1954 did not reduce stand or fresh weight of these crops noticeably.

Results of these plantings indicated that the rates of 10 to 50 pounds were dissipated sufficiently in the soil in 24 months to allow normal growth of these crops.

Discussion of Results

The results of these trials, as measured by plant response, demonstrated that rates of up to 5 pounds of CMU per acre mixed thoroughly in the top 5 inches of a sandy clay loam soil at the time of application were dissipated sufficiently in a 3-month period so that snap beans, sweet corn and spinach planted in the treated areas did not show visible or measurable injury. Rates of 20 to 50 pounds per acre were still active 12 months after treatment but were dissipated in a 24-month period.

Table 5. Effect of high rates of application of CMU on emergence and growth of sweet corn and snap beans.

CMU lb/A[1]	Sweet corn					Snap beans				
	Elapsed time—treatment to planting					Elapsed time—treatment to planting				
	1 mo.	2 mo.	3 mo.	12 mo.	24 mo.	1 mo.	2 mo.	3 mo.	12 mo.	24 mo.
	Av. stand per tile									
0	8.0	8.8	8.5	9.0	8.8	5.8	7.8	7.0	8.0	7.2
0 + W	7.6	9.6	9.6	9.2	8.8	6.2	8.0	7.6	8.8	9.2
10	0.4	2.6	8.2	8.8	9.2	1.6	2.2	6.2	8.4	8.6
10 + W	0.2	5.4	8.8	9.0	8.4	0.4	4.2	4.4	8.4	9.6
15	0	0.8	4.8	8.2	9.4	1.4	0.6	1.8	7.8	9.0
15 + W	0.4	0.8	5.6	9.8	9.8	0	0	3.4	8.4	9.2
20	0	0	1.2	8.6	8.8	0.2	0	1.2	6.6	8.8
20 + W	0	0	3.2	9.0	9.4	0.2	0.2	0	7.4	9.0
25	0	0	0	5.8	8.6	0.6	0	0	3.6	8.8
25 + W	0	0	1.2	9.6	8.8	0	0	0.4	7.8	9.6
50	0	0	0	4.8	9.4	0	0	0	1.8	7.8
50 + W	0	0	0	6.8	8.8	0	0	0	1.6	9.2
L.S.D. 5%	1.8	1.9	2.0	2.6	N.S.	2.2	2.1	5.0	2.8	N.S.
1%	2.4	2.5	2.3	3.4	N.S.	3.0	2.8	6.5	3.7	N.S.
	Av. fresh wt. of tops—gms.									
0	26.9	19.1	4.7	28.1	24.5	4.3	14.1	7.6	13.7	13.6
0 + W	33.9	17.7	5.8	27.7	26.0	6.4	12.0	6.8	11.5	12.7
10	1.3	0.6	1.9	19.0	19.8	2.6	0.6	3.9	10.9	9.6
10 + W	0.2	0.9	2.5	30.7	27.0	0.6	1.1	2.9	13.8	12.3
15	0	0.2	1.5	20.0	18.4	1.5	0.2	1.0	8.8	10.8
15 + W	0.4	0.6	1.9	18.8	26.7	0	0.5	0.8	6.9	13.0
20	0	0	0.6	8.3	22.3	0.6	0	1.4	4.3	10.5
20 + W	0	0	0.3	21.0	26.6	0.6	0.2	0	8.2	14.4
25	0	0	0	3.4	19.4	0.6	0	0	8.2	9.8
25 + W	0.1	0	0	15.8	23.7	0	0	0	4.3	14.6
50	0	0	0	1.4	17.3	0	0	0	0.4	11.0
50 + W	0	0	0	3.5	22.9	0	0	0	0.5	13.3
L.S.D. 5%	9.7	5.2	1.4	4.6	6.4	2.2	3.4	2.4	2.0	3.2
1%	12.7	6.9	1.9	6.1	8.4	2.9	4.6	3.1	2.6	4.2

[1] "W" indicates irrigation in addition to rainfall.

Principal results of the study were obtained in the first 3-month period when it was found that weedkilling rates of application, namely, 1 and 2 pounds of CMU per acre, appeared to lose their phytotoxicity rather quickly in the soil. These results offered encouragement for the use of these low rates in successive seasons without fear of cumulative effects. The validity of this idea was tested further by re-treating the low rate plots twice at 12-month intervals. This represented 3 applications of each of these rates up to 5 pounds per acre in 24 months. Plantings made at the time of these final treatments indicated that cumulative effects of previous treatments were not present as shown by plant growth.

These data on CMU residues in the soil as measured by plant response, while not conclusive, are certainly strongly indicative of a rapid detoxification of weedkilling concentrations of the chemical in a sandy clay loam soil.

The detoxification of 50 pounds of CMU per acre in a 2-year period was surprising. Detoxification may have been hastened by mixing the chemical with the top 5 inches of soil. This distribution exposed the chemical to a large volume of soil as compared to a very limited soil exposure when a chemical is applied on the soil surface and allowed to remain there.

Comparison of stands in irrigated and non-irrigated plots indicated that irrigation in addition to the rainfall experienced during the trials did not materially affect the rate of detoxification of CMU in the soil though some slight increases in fresh weight resulted from moisture accumulation in certain instances.

Differences in results between wet and dry applications of CMU showed that a more toxic effect was achieved with dry applications in pyrophyllite than with water suspensions of the chemical. No explanation for this can be offered but it merits further study to determine whether this was an isolated incident or represents the expression of a general relationship between method of application and phytotoxicity.

Snap beans and sweet corn were not affected appreciably by pre-emergence applications of 1 pound of CMU per acre. Excellent control of annual grasses and many broadleaf weeds can be obtained with this rate and time of application. This suggests that CMU may prove practical for these crops in the future.

SUMMARY

1. Applications of practical weedkilling rates of 1 and 2 pounds of CMU per acre did not remain in a sandy clay loam soil in sufficient strength from one season to another to be toxic to snap bean or sweet corn seedlings.

2. Applications of as much as 50 pounds of CMU per acre were dissipated sufficiently in 24 months to allow normal early vegetative growth of the test crops, snap beans and sweet corn, in a sandy clay loam soil.

3. Irrigation in addition to natural rainfall did not affect the rate of detoxification of CMU applied in the manner described in a sandy clay loam soil as measured by the emergence and persistance of test crop seedlings.

4. Snap beans, sweet corn and spinach were found to be quite tolerant of a pre-emergence application of 1 pound of CMU per acre in a sandy clay loam soil having an organic matter content of 2.21 percent.

5. The need for a study of wet and dry applications of CMU to determine their relative effectiveness was indicated.

LITERATURE CITED

1. BUCHA, H. C., and TODD, C. W. 3-(*p*-chlorophenyl)-1,1-dimethylurea-a new herbicide. Science 114:493. 1951.
2. DALLYN, S. The effect of soil organic matter levels on several herbicides. Proc. Northeastern Weed Control Conf., pp. 13–20. 1954.
3. DANIELSON, L. L., and EASLEY, LILA W. Progress report on the crop toxicity period of CMU in a sandy loam soil. Proc. Northeastern Weed Control Conf., pp. 11–15. 1953.
4. DOLAN, D. D. Factors determining the effectiveness of pre-emergence herbicidal treatments. Proc. Northeastern Weed Control Conf., pp. 77–82. 1954.
5. FOY, C. L., HOYT, J., and LEONARD, O. A. Comparative efficiency of CMU and other residual type herbicides applied at lay-by for late season weed control in irrigated cotton. Proc. Southern Weed Conf., pp. 93–96. 1954.

6. HALE, M. C., CHAPPELL, W. E., and HULCHER, F. H. Effect of certain herbicides on the O_2 up-take by soil previously enriched with nitrifiers. Proc. Northeastern Weed Control Conf., pp. 23–28. 1954.
7. HILL, G. D. Substituted ureas for pre-emergence weed control in cotton-soil relationships. Proc. Southern Weed Conf., pp. 76–87. 1954.
8. ———, MCGAHEN, J. W., BAKER, H. M., FINNERTY, D. W., and BINGEMAN, C. W. The fate of substituted urea herbicides in agricultural soils. Agron. Journ. 47:93–104. 1955.
9. LINDER, P. J. Movement and persistance of herbicides following their application to the soil surface. Proc. Northeastern Weed Control Conf., pp. 7–11. 1952.
10. LOUSTALOT, A. J., MUZIK, T. J., and CRUZADA, H. J. Persistance of CMU in soil. Agr. Chem. 8:52. 1953.
11. OGLE, R. E., and WARREN, G. F. Fate and activity of herbicides in soils. Weeds. Vol. 3:257–273. 1954.
12. Report of the research committee of the Southern Weed Conference for 1954. Proc. Southern Weed Conf., pp. 329–336. 1954.
13. WILLARD, C. J. Review of work with CMU as an herbicide. Proc. North-Central Weed Control Conf., pp. 101–102. 1952.
14. WOLF, D. E. CMU—a new herbicide. Proc. North Central Weed Control Conf., pp. 104. 1951.

Studies on the Control of Crabgrass in Bluegrass Lawns[1]

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WEED CONTROL is one of the principal problems of turf grass management. With the discovery that 2,4–D would selectively kill many broad-leaved weeds their control in turf has been minimized. As has been indicated by Grigsby (9), the widespread usage of 2,4–D may be an important factor in increasing the importance of crabgrass *(Digitaria* spp.) as a turf weed.

In recent years, a large number of studies have been carried out in attempts to discover chemicals that would effectively control crabgrass in turf. In 1935, sodium arsenite was reported (19) to be effective as a selective crabgrass killer. Later reports have indicated sodium arsenite to be ineffective (14) or as having given only fair control (5, 6) of crabgrass. Likewise, arsenic acid has given only poor to fair control and has caused excessive turf discoloration (21, 26). In 1947, De France (2) first reported on the effectiveness of phenyl mercuric acetate (PMA) as a selective crabgrass killer for use in turf. Since then, a number of workers have reported generally good crabgrass control with PMA (3, 4, 5, 6, 12, 13, 14, 15, 16, 21, 22, 23, 24, 26, 27, 29, 38). However, most of these reports also indicated that PMA caused some discoloration of the desirable turf grasses.

A number of other chemicals have also been reported to be effective selective crabgrass killers in turf. Potassium cyanate (KOCN) has been reported (3, 5, 7, 14, 15, 16, 20, 21, 27, 29, 30) to give good to excellent crabgrass control with only slight (6, 7, 30) to moderate (5, 20, 27) temporary discoloration of the turf grasses. A mixture of KOCN and organic nitrogen fertilizer, has resulted in good crabgrass control without turf grass discoloration (3, 15, 16). Various derivatives of boronium fluoride have been shown (3, 4, 5, 27) to be effective as selective crabgrass killers although they have been reported (4, 5) to cause excessive discoloration of desirable turf grasses. Chlordane, when applied in oil, has been reported to give fair (16, 24) to good (9, 10) crabgrass control with only slight (24) or no (10) turf discoloration. When used in water, chlordane is apparently ineffective (10, 17). Maleic hydrazide (MH) has been reported (21, 22, 29) to be ineffective in controlling crabgrass. Disodium methylarsonate in one report (7) gave excellent crabgrass control with no injury to desirable turf grasses.

Various petroleum oils have been tried as crabgrass killers with varying results. Kerosene has been reported to give good (1, 6) to fair control (22) but, in general, has caused excessive discoloration of turf grasses (1, 6, 22). Stoddard solvent has given good crabgrass control (8, 11, 22, 23) but moderate (8, 23) to severe (22) discoloration of other turf grasses. Standard Crabgrass Killer, another petroleum oil of the naphtha type, has been reported to give good (8) and poor

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(22, 24) control with injury to other turf grasses varying from severe (22) to none (8).

Various herbicides have been tried in attempts to control crabgrass before it emerges. Dichloral urea (DCU) has given crabgrass control varying from good (12, 16, 21, 25) to poor (22) with little or no turf injury (12, 22, 25). N–1–naphthyl phthalamic acid (NPA) has given good (12) to fair (24) control with only slight to moderate bluegrass injury. In one experiment (12), sodium 2,4,5–trichlorophenoxyethyl sulphate (2,4,5–TES) gave good control; in another (16) no control. PMA gave good control when applied pre-emergence (12, 13). 2,4–Dichlorophenoxyethyl sulphate (2,4–DES) gave good control in one experiment (16) and fair control in another (24). 2,4–Dichlorophenoxyethyl benzoate (2,4–DEB) in one study (18) gave excellent crabgrass control while in another (16) it was ineffective.

The present paper is a report of four-years' results with some crabgrass killers, and an attempt to explain variations in selectivity of some of them on the basis of the environmental conditions prevailing during these years.

MATERIALS AND METHODS

Crabgrass control trials were conducted during the summers of 1950, 1951, 1954, and 1955 at University Farm on a large bluegrass lawn heavily infested with crabgrass. In every year except 1951 each treatment was applied to quadruplicated plots each 100 square feet in area. In 1951, 8 replications of plots 5 x 10 feet in size were used. All herbicides were applied at 30 to 50 psi pressure using a knapsack spraver and flat-spray nozzle.

Effects of the herbicides on crabgrass were determined by a count of live crabgrass plants in square-foot areas in each plot in 1951 and 1954. In 1950 and 1955, crabgrass control was determined by use of a rating system in which 0 = 0% control, 1 = 20% control, 2 = 40% control, 3 = 60% control, 4 = 80% control, and 5 = 100% control.

Effects of the herbicides on bluegrass were determined by use of a rating scale in which 0 = no discoloration, 1 = slight discoloration, 2 = moderate discoloration, 3 = severe discoloration, 4 = very severe discoloration, and 5 = bluegrass dead. The time at which crabgrass control and bluegrass injury data were obtained varied from year to year but in general included readings 1 week after the final herbicide application and again 3 to 4 weeks later.

The lawn area in which the experimental plots were located was, in general, mowed to a height of 1–1½ inches a day or two before herbicides were applied. During dry spells the lawn was watered with rotary sprinklers, but no attempt was made to record the dates or amounts of water applied.

Precipitation and temperature data were obtained from records of the U. S. Weather bureau station at Wold-Chamberlain Airport approximately 9 miles from University Farm.

RESULTS

In 1950, 10 herbicides were applied as post-emergence treatments starting on July 13 when crabgrass was in the 2- to 4-leaf stage. The herbicides applied were: PMA, bis(lauryl, di–2–hydroxy–ethyl amino) boronium fluoride (S–1998), KOCN, sodium trichloroacetate (TCA), MH, DCU, Stoddard solvent, kerosene, Standard Crabgrass Killer, and L–2687. The latter 4 are petroleum oils. As indicated in Table 1, some of the herbicides were applied once, some twice, and some three times to the same area. Table 1 gives the estimated percent control of crabgrass one week after the last herbicide application. Of the herbicides tested, only Stoddard solvent, kerosene, PMA, and S–1998 gave good control of crabgrass and, of these, only the latter 2 caused no lasting injury to the bluegrass. In 1950, temperatures during the 14 day period following first herbicide application averaged 68.5° F., and on none of these days did the maximum temperature exceed 85° F. Precipitation during this period was 2.61 inches.

Table 1. Crabgrass control and bluegrass injury resulting from the application of various herbicides, 1950.

Herbicides applied	Rates of herbicide and water/acre[1]	Dates of application	Observations on July 29	
			Crabgrass control—%	Bluegrass injury rating
PMA	0.8 lbs. in 87 gal.	July 13, 20	96	0
S-1998	18.75 lbs. in 360 gal.	July 13, 17, 21	96	0
Stod. solvent	80 gal. (no water)	July 13	96	0.8
Kerosene	120 gal. (no water)	July 13, 20	84	1.0
KOCN	8 lb. in 305 gal.	July 13, 23	69	0
TCA(Na-salt)	10 lbs. in 80 gal.	July 13	60	1.0
St'd C. G. Killer	80 gal. (no water)	July 13, 23	30	0.2
L-2687	80 gal. (no water)	July 13, 23	24	0.2
MH	0.3% sol'n in 160 gal.	July 13	16	0
DCU	5 lbs. in 80 gal.	July 13, 23	10	0

[1]Active ingredient basis except S-1998.

In 1951, 5 herbicides were applied as postemergence treatments starting on June 28 when crabgrass had 2–4 leaves. The herbicides applied were: Stoddard solvent at 2 rates, PMA, monoamino boronium fluoride (S–1840M), KOCN, and sodium arsenite. Table 2 gives the percentage of crabgrass control, as obtained by counts in square foot areas in each replicate, and bluegrass injury ratings 1 week after the final herbicide application. Stoddard solvent at lower rates of 40 and 60 gallons per acre gave excellent crabgrass control, as did the 80 gallon rate in 1950, but caused less bluegrass injury. PMA, KOCN, and S–1840M also gave good crabgrass control but caused somewhat more bluegrass discoloration. One month after the herbicides were applied, no bluegrass injury was apparent in any of the plots. As in 1950, temperatures for the 14-day period following first herbicide application were moderate, averaging 67.0° F., and only one day had a maximum temperature exceeding 85.° F. Precipitation, however, was only 0.42 inches as compared to the 2.61

inches obtained in 1950. The lower precipitation in 1951 apparently did not affect weed control obtained, as indicated by comparisons with the 1950 data.

Table 2. Crabgrass control and bluegrass injury resulting from the application of various herbicides, 1951.

Herbicides applied	Rates of herbicide and water/acre[1]	Dates of application	Observations on July 11	
			Crabgrass control—%	Bluegrass injury rating
Stoddard solvent	60 gal. (no water)	June 28	91	0.2
Stoddard solvent	40 gal. (no water)	June 28	83	0.2
PMA	0.5 lb. in 100 gal.	June 28, July 5	85	1.1
S-1840M	17.5 lb. in 200 gal.	June 28, July 5	85	1.0
KOCN	8 lb. in 100 gal.	June 28, July 5	75	1.6
Sodium arsenite	1 lb. in 100 gal.	June 28, July 5	52	1.8

[1]Active ingredient basis except S-1840 M.

In 1954, 4 pre-emergence herbicides (NPA, 2,4–DES, chlordane and PAX) and 3 post-emergence herbicides (KOCN, PMA, and Standard Crabgrass Killer) were applied. The pre-emergence treatments were begun on June 8, approximately 3 weeks prior to first emergence of crabgrass in the experimental area; the post-emergence treatments were begun on July 7, 1 week after the first crabgrass emergence.

Table 3 gives the percentages of crabgrass control obtained, based on weed counts, and the ratings of injury to bluegrass. These data were obtained approximately 1 month after the last pre-emergence treatment and 2 weeks after the last post-emergence treatment. All herbicides except Standard Crabgrass Killer and PAX significantly reduced crabgrass stands. KOCN was the most effective crabgrass killer, followed by PMA and NPA. In contrast to the moderate temperatures following herbicide applications in 1950 and 1951, temperatures for the 14-day period following post-emergence applications in 1954 were relatively high, averaging 76.6° F. and on 7 of these days the maximum temperature exceeded 85° F. Rainfall

Table 3. Crabgrass control and bluegrass injury resulting from the application of various pre- and post-emergence herbicides, 1954.

Herbicides applied	Rates of herbicide and water/acre[2]	Dates of application	Observations on August 3	
			Crabgrass control—%	Bluegrass injury rating
Pre-emergence				
NPA	8 lb. in 170 gal.	June 8, July 6	75	1.2
2,4-DES	8 lb. in 200 gal.	June 8, July 6	66	0
Chlordane	15 lb. in 43 gal. oil	June 8, July 6	66	0
PAX[1]	2178 lb. (dry)	June 8	53	1.0
Post-emergence				
KOCN	8 lb. in 100 gal.	July 7, 14	97	0.2
PMA	0.5 lb. in 100 gal.	July 7, 14	75	1.0
St'd C.G. Killer	107 gal. (no water)	July 7, 22	41	4.0

[1]Contains 13.2 percent lead arsenate and 3 percent nitrogen.
[2]Active ingredient basis.

during this period totalled only 0.30 inches. Under these hot, dry conditions KOCN was somewhat more effective than PMA in controlling crabgrass. In spite of the fact that the plots were irrigated after application of the pre-emergence herbicides on June 8, under the hot, dry conditions which prevailed during June and July the pre-emergence herbicides were less effective than KOCN.

In 1955, 7 pre-emergence and 6 post-emergence herbicides were included in the crabgrass control trial. The herbicides applied as pre-emergence treatments were: 2,4–DEB, N–1–naphthyl phthalamic acid plus urea (Alanap 1F), tris–(2,4–dichlorophenoxy ethyl) phosphite (Naugatuck 3Y9), 3(3,4–dichlorophenyl)–1–methyl–1–n–butyl urea (DuPont No. 1), DCU, 2,4–DES, and chloro–N,N–diethyl acetamide (CDEA). The post-emergence herbicides were: PMA, disodium methylarsonate, KOCN, Milcyanate (4% KOCN + 96% Milorganite), Standard Spray C (a petroleum oil containing chlordane), and Standard Crabgrass Killer. The pre-emergence treatments were begun on June 10 when a few small crabgrass plants were visible in the plot area. The post-emergence treatments were begun on June 24 when crabgrass plants were in the 3–4 leaf stage. The 2 oils, Standard Crabgrass Killer and Standard Spray C, were applied first on July 22 when crabgrass was in the "boot" stage. Crabgrass control and bluegrass injury were estimated on July 22, 2 weeks after the last post-emergence treatment and again on August 23, 1 month after the last pre-emergence treatment. Table 4 gives the crabgrass control and bluegrass injury data obtained on these dates with the various treatments. Of the pre-emergence treatments, only 2,4–DEB gave a fair measure of crabgrass control (76%) after

Table 4. Crabgrass control and bluegrass injury resulting from the application of pre- and post-emergence herbicides, 1955.

Herbicides applied	Rates of herbicide per acre[1]	Dates of application	Date of observations			
			July 22		August 23	
			Crabgrass control pct.	Bluegrass injury	Crabgrass control pct.	Bluegrass injury
Pre-emergence						
2,4-DEB	8 lb.	June 10, July 1, 22	76	2.0	50	2.2
Alanap 1F	784 lb. (dry)	June 10, July 1, 22	60	0	40	2.0
Naugatuck 3Y9	4 lb.	June 10, July 1, 22	60	1.0	30	1.2
DuPont No. 1	4 lb.	June 10	56	1.0	6	1.0
DCU	10 lb.	June 10	44	1.2	30	1.2
2,4-DES	8 lb.	June 10, July 1, 22	30	0.2	20	0
CDEA	6 lb.	June 10	0	0	0	0
Post-emergence						
PMA	0.9 lb.	June 24, July 1, 8	100	3.0	56	2.5
Disod. methylarsonate	8 lb.	June 24, July 1, 8	96	3.5	44	3.0
KOCN	8 lb.	June 24, July 1, 8	70	2.2	20	1.2
Milcyanate	653 lb. (dry)	June 24, July 1, 8	56	3.0	6	2.2
Standard Spray C	108 gal.	July 22, Aug. 5	—	—	76	3.0
Standard C.G. Killer	108 gal.	July 22, Aug. 5	—	—	16	3.0

[1]Active ingredient basis except Milcyanate and Alanap 1F. All herbicides except oils and dry materials applied in 100 gal. water.

two applications. One month after the third application, it was still the best pre-emergence treatment but gave only 50% control and showed the greatest degree of bluegrass injury.

Of the post-emergence treatments, PMA and disodium methylarsonate gave excellent crabgrass control as measured 2 weeks after the last application. However, hot, wet weather during late July and early August resulted in a second period of germination of crabgrass that reinfested the plots treated with pre-emergence and early post-emergence herbicides. Standard Spray C, applied during this reinfestation period, killed a high percentage of both the early- and late-germinated crops of crabgrass seedlings.

All of the post-emergence treatments applied in 1955 caused considerable blue-grass discoloration. This was probably due to the extremely hot weather which followed the herbicide applications. From the date of first post-emergence application, June 24, to 7 days after the third application on July 8 the mean temperature was 75.6° F. and 11 of these 21 days had maximum temperatures over 85° F. Precipitation during this period totalled 5.77 inches of which 4.07 inches fell on July 7 and 8. Under these conditions, the herbicides were highly toxic to crabgrass and regrowth of bluegrass was slow.

Relation of climatic factors to crabgrass development and to herbicide effectiveness and selectivity. The wide variations in temperature and moisture conditions during the four years of the present study make it possible to determine the extent to which weather conditions influenced crabgrass emergence and development, herbicide effectiveness, and bluegrass injury.

Toole and Toole (28) have shown that high temperatures are necessary for crabgrass germination. In their studies, germination of one-year-old seed was more than 90 percent and was practically completed in 14 days at alternating temperatures of 20 and 40° C. while at alternating temperatures of 15 and 25° C. germination was less than 50 percent in 56 days. In the present study crabgrass development varied considerably in the years 1950, 1951, 1954 and 1955.

In order to determine the relation of temperature to crabgrass emergence and development during these years, the accumulated degree days[1] above a base temperature of 60° F. from May 1 to the date when crabgrass reached the 2- to 4-leaf stage were plotted for each of the 4 years. These data are shown in Figure 1. May was cool in 1954 (37 degree days) as compared to 1955 (161 degree days) and crabgrass emerged 21 days later in 1954 than in 1955. In the 2 years (1951 and 1955) in which May was relatively warm (118 and 161 degree days, respectively) crabgrass reached the 2- to 4-leaf stage between June 20 and June 30. In contrast, in the 2 years (1950 and 1954) in which May was relatively cool (56 and 37 degree days, respectively), crabgrass reached the 2- to 4-leaf stage between July 7 and July 13.

[1]Degree days = mean temperature for the day minus the base temperature.

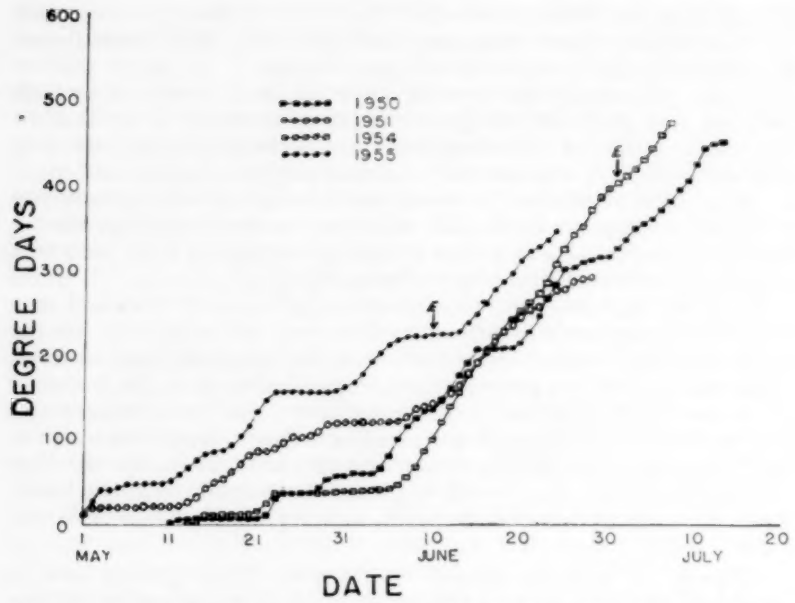

Figure 1. Accumulated degree days (above 60° F.) from May 1 to date when crabgrass had 2–4 leaves for 4 seasons. In 1954 and 1955, crabgrass emerged on date indicated by 'E'.

An examination of precipitation data during May and June of the 4 years indicated no relationship between crabgrass development and rainfall. In 1950, 1954, and 1955 total rainfall during May and June was considerably below normal, particularly in 1955, while rainfall during these months in 1951 was above normal.

Two herbicides, PMA and KOCN, were applied in all 4 years of the study. Association between environmental variables and crabgrass control with these herbicides varied with the herbicide applied. Table 5 shows the crabgrass control and bluegrass injury which resulted from the application of PMA and KOCN in each of the 4 years together with mean temperatures, number of hot days, and precipitation during the 14-day period following herbicide application.

PMA gave the best crabgrass control under moderately cool, moist conditions (1950); was somewhat less effective under cool, dry conditions (1951); and was least effective under hot, dry conditions (1954 and 1955). That drouth apparently reduced the effectiveness of PMA is indicated by the fact that a third application made on July 8 following a heavy rain during the night of July 7 resulted in 100% crabgrass control (Table 4).

KOCN was relatively less effective than PMA under the cool conditions of 1950 and 1951, but gave good control under the hot, dry conditions of 1954. However, KOCN gave poor crabgrass control

Table 5. Comparison of crabgrass control and bluegrass injury resulting from applications of PMA and KOCN during 4 seasons together with temperature and precipitation data for the 14-day period following herbicide application.

Observation	Year			
	1950	1951	1954	1955
Crabgrass control(pct.) with[1]				
PMA	96	85	75	76
KOCN	60	75	97	44
Bluegrass injury from:				
PMA	0	1.1	1.0	2.5
KOCN	0	1.6	0.2	1.8
Mean temperatures:				
On day of 1st application	62	61	73	70
1st day following application	70	64	75	68
2nd day following application	71	61	72	70
3rd day following application	71	63	74	72
4th day following application	69	68	81	75
5th day following application	71	65	82	77
6th day following application	61	63	82	82
7th day (day of 2nd application)	66	69	74	78
8th day following 1st application	68	68	74	77
9th day following 1st application	71	77	78	81
10th day following 1st application	66	75	77	81
11th day following 1st application	69	72	76	79
12th day following 1st application	73	64	80	81
13th day following 1st application	71	68	75	78
Mean	68.5	67.0	76.6	76.4
Days having maximum above:				
85°F	0	1	7	9
90°F	0	0	3	5
Total precipitation (inches) during the above 14 days	2.61	0.42	0.30	3.73[2]

[1]Crabgrass control and bluegrass injury data taken 3 weeks after last spraying in 1954; in other years, data taken one week after spraying.
[2]3.00 in. fell on 14th day.

in 1955 under conditions similar to those of 1954. As with PMA, however, a third application of KOCN on July 8 following a heavy rain resulted in considerably better crabgrass control (Table 4).

Both herbicides caused the greatest injury to bluegrass under the hot, dry conditions of 1955, somewhat less injury under the cool, dry conditions of 1951, and no injury under the cool, moist conditions prevailing in 1950 (Table 5). The data for 1954 (Table 5) indicate relatively less bluegrass injury in 1954 and in 1955, but inasmuch as these data were recorded 3 weeks instead of 1 week after treatment, it is possible that the bluegrass had already recovered to a great extent in this experiment. Considering the differences in bluegrass injury following herbicide applications in 1950 and 1951, it appears that during cool weather adequate soil moisture during and following herbicide application minimizes bluegrass discoloration. On the other hand, during hot weather, adequate soil moisture during and following herbicide application may increase the amount of bluegrass injury as evidenced by comparison of bluegrass injury in 1955 during dry weather (Table 5) with injury which resulted from an herbicide application made during high soil moisture conditions (Table 4).

DISCUSSION

Crabgrass control trials were conducted over a period of 4 years, 2 of which (1950 and 1951) were characterized by relatively cool weather and 2 by relatively hot weather (1954 and 1955). Under these varying conditions, KOCN and PMA applied as postemergence herbicides controlled 76 percent and 89 percent of the crabgrass, respectively, over the 4 year period. Standard Crabgrass Killer, a petroleum oil, gave poor crabgrass control in all 3 years in which it was tested. Another petroleum oil, Stoddard solvent, gave excellent crabgrass control in the 2 cool years when it was tested. Unfortunately, this herbicide was not tested during the 2 warm years, 1954 and 1955. Two boronium fluoride compounds (S–1998 and S–1840 M) also gave good crabgrass control in the 2 cool years when they were tested, but were not tested during the 2 warm seasons. Disodium methylarsonate gave good crabgrass control but caused excessive bluegrass injury in the 1 year when it was tested. However, during this warm year both KOCN and PMA also caused excessive bluegrass injury.

As a late post-emergence treatment, Standard Spray C, a petroleum oil containing chlordane, gave good crabgrass control but excessive bluegrass injury in the warm season of 1955. Pre-emergence treatments were tried only during the last 2 years of tests (1954 and 1955) both of which were characterized by unusually warm weather. Under these conditions, none of the pre-emergence treatments gave outstanding crabgrass control. The most promising of the pre-emergence herbicides tested appear to be NPA, 2,4–DEB, chlordane and Naugatuck 3Y9.

Engel, et al. (5) have pointed out that under conditions unfavorable for growth of turf grasses, i.e. hot and dry weather, injury from herbicides is greater than under conditions favorable for turf, i.e. cool and moist. On the basis of the results of the present study, to their statement could be added the fact that under hot, wet weather injury to bluegrass is even greater than under hot, dry weather.

SUMMARY

1. Over a period of 4 years, 24 herbicides were tested for their effectiveness in the control of crabgrass in a bluegrass lawn. Two of these herbicides, potassium cyanate (KOCN) and phenyl mercuric acetate (PMA), were tested in all 4 years.

2. Two to three applications of KOCN applied at 8 lb/A after emergence of the crabgrass killed an average of 76 percent of the crabgrass present.

3. Two to three applications of PMA applied at 0.5 to 0.9 lb/A killed an average of 89 percent of the crabgrass present.

4. Other herbicides which gave fair to good crabgrass control but were not as thoroughly tested include Stoddard solvent, 2 boronium fluoride formulations (S–1998 and S–1840 M), NPA, disodium methylarsonate, chlordane in a petroleum oil (Standard Spray C), chlordane in oil, 2,4–DEB, and Naugatuck 3Y9.

5. In 1955, when the month of May was unusually warm (161 degree days above 60° F.), crabgrass emerged on June 10, while in 1954, when May was unusually cool (37 degree days), crabgrass emerged on July 1.

6. In the 2 years (1951 and 1955) in which May was relatively warm (118 and 161 degree days, respectively) crabgrass reached the 2- to 4-leaf stage between June 20 and June 30. In the 2 years (1950 and 1954) in which May was cool (56 and 37 degree days, respectively) crabgrass reached the 2- to 4-leaf stage between July 7 and July 13.

7. PMA was more toxic to crabgrass and less toxic to bluegrass under cool weather conditions than under hot weather conditions.

8. KOCN was more toxic to crabgrass in one of the 2 hot seasons than under cool weather conditions but not in the other. In both hot seasons KOCN was more toxic to bluegrass than in the cool seasons.

9. Both PMA and KOCN caused more injury to bluegrass under hot, moist conditions than under hot, dry conditions.

LITERATURE CITED

1. BOHMONT, D. W., and KLINGMAN, D. L. Control of crabgrass seedlings in established bluegrass lawn with shale oil and petroleum fractions. Res. Report, North Central Weed Control Conf., p. 39. 1951.
2. DEFRANCE, J. A. Water-soluble mercurials for crabgrass control in turf. The Greenskeeper's Reporter 15:30–31. 1947.
3. ———, and HART, S. W. Chemical control of mature smooth crabgrass in lawns. Proc. Northeastern Weed Control Conf., pp. 381–384. 1954.
4. ENGEL, RALPH E., and WOLF, D. E. Results of testing chemicals for crabgrass control in 1949. Proc. Northeastern Weed Control Conf., pp. 239–243. 1950.
5. ———, ALDRICH, RICHARD J., and AHLGREN, GILBERT H. A comparison of five chemicals for crabgrass control in turf. Weeds 2:27–32. 1953.
6. FINNERTY, D. W. Chemical control of crabgrass in a bluegrass lawn. Res. Report, North Central Weed Control Conf., pp. 41–42. 1951.
7. GALLAGHER, JOHN E., and EMERSON, BARBARA H. Crabgrass control observations for 1954. Proc. Northeastern Weed Control Conf., pp. 385–389. 1955.
8. GRIGSBY, BUFORD H. Control of crabgrass (*Digitaria* spp.) by the use of chemical sprays. Mich. Agr. Exp. Sta. Quart. Bul. 32:479–485. 1950.
9. ———. Use of chlordane as an aid to the control of crabgrass by oil sprays. Res. Report, North Central Weed Control Conf., p. 42. 1951.
10. ———. Effects of chlordane on crabgrass in turf. Res. Report, North Central Weed Control Conf., p. 142. 1952.
11. ———. Removal of mature crabgrass prior to fall reseeding of turf. Res. Report, North Central Weed Control Conf., p. 152. 1953.
12. HART, S. W., and DEFRANCE, J. A. The pre-emergence control of smooth crabgrass with chemicals. Proc. Northeastern Weed Control Conf., pp. 345–351. 1955.
13. LANTZ, H. L. Crabgrass control in specialized turf areas. Res. Report, North Central Weed Control Conf., p. 130. 1950.
14. ———. Experiments with chemical control of crabgrass in 1951. Res. Report, North Central Weed Control Conf., p. 44. 1951.
15. ———. Chemical control of crabgrass in turf. Res. Report, North Central Weed Control Conf., p. 143. 1952.
16. ———. Crabgrass control trials in 1954. Res. Report, North Central Weed Control Conf., pp. 100–101. 1954.

17. LEE, OLIVER C. Response of crabgrass in bluegrass turf to chlordane. Res. Report, North Central Weed Control Conf., p. 143. 1952.
18. ———. Response of crabgrass in turf to 2,4-dichlorophenoxyethyl benzoate. Res. Report, North Central Weed Control Conf., p. 101. 1954.
19. MONTEITH, JOHN, JR., and BENGSTON, JOHN W. Arsenical compounds for the control of turf weeds. Turf Culture 1:63–79. 1939.
20. NUTTER, E. C., and CORNMAN, J. F. Experiments in crabgrass control with potassium cyanate. Proc. Northeastern Weed Control Conf., pp. 225–230. 1950.
21. ———, and ———. Comparative studies with crabgrass herbicides in turf. Proc. Northeastern Weed Control Conf., pp. 143–149. 1951.
22. NYLUND, R. E. A study on the value of herbicides for the control of crabgrass in turf. Res. Report, North Central Weed Control Conf., pp. 130–131. 1950.
23. ———. Studies on the control of crabgrass in lawns. Res. Report, North Central Weed Control Conf., pp. 44–45. 1951.
24. ———. Crabgrass control in bluegrass turf. Res. Report, North Central Weed Control Conf., p. 101. 1954.
25. ROBINSON, E. L., and WILLARD, C. J. Control of crabgrass in lawns. Res. Report, North Central Weed Control Conf., pp. 45–46. 1951.
26. SLIFE, F. W. Control of crabgrass with chemicals. Res. Report, North Central Weed Control Conf., Abstract No. 81. 1948.
27. ———. Chemicals for crabgrass control in turf. Res. Report, North Central Weed Control Conf., p. 46. 1951.
28. TOOLE, EBEN H., and TOOLE, VIVIAN KEARNS. Progress of germination of seed of *Digitaria* as influenced by germination temperature and other factors. Jour. Agr. Res. 63:65–90. 1941.
29. WAYWELL, C. G. A summary of four years results on crabgrass control in Ontario. Proc. Northeastern Weed Control Conf., pp. 263–266. 1953.
30. ———, and BIBBEY, R. O. Potassium cyanate, phenyl mercuric acetate and maleic hydrazide in the control of crabgrass. Proc. Northeastern Weed Control Conf., pp. 155–160. 1951.

A Note on the Sugars and Amino Acids of Leafy Spurge, *Euphorbia esula*[1]

DUANE LE TOURNEAU[2]

IT HAS been shown that extracts of various weeds and crop plants inhibit germination and seedling growth (1, 4, 5, 7). In early experiments (7) it appeared that extracts of leafy spurge *(Euphorbia esula)* were particularly effective. For this reason it was of interest to more fully characterize the composition of leafy spurge. The present communication summarizes the results of qualitative paper chromatographic determinations for amino acids and sugars.

Ten-gram samples of stems and leaves were killed and extracted with 80% ethanol. The alcoholic extract, adjusted to 10 ml. under reduced pressure, was used for determination of the free sugars and amino acids. The insoluble residue following extraction was air dried and ground to pass through a 40-mesh screen. Combined sugars were determined on the alcohol-insoluble residue following hydrolysis of one-gram samples with 1 *N* HCl for 10 hours, while combined amino acids were determined on one-gram samples hydrolyzed 16 hours in 8 *N* HCl. Hydrolysates were concentrated to dryness under reduced pressure and adjusted to 10 ml.

Sugars were determined and identified by comparison to known materials by one-dimensional descending chromatography using three irrigants (ethyl acetate-pyridine-water (2/1/2, v/v/v), butanol-ethanol-water (4/1/5, v/v/v), and phenol-water) and three detecting sprays (aniline hydrogen oxalate, 2 per cent resorcinol in 2 *N* HCl, and ammoniacal silver nitrate). Amino acids were determined and identified by two-dimensional descending chromatography according to the method of Dent (3).

Sucrose and glucose were the predominant free sugars, while lesser amounts of fructose were present. Other materials reacted with the ammoniacal silver nitrate but not with the two more specific sprays, and they did not conform in position with known sugars. These results agree in general with those obtained with other plant tissue. Bidwell (2) chromatographically examined the free sugars of various species of plants representing 27 families. These did not include representatives of the *Euphorbiaceae*. He found that these plants contained primarily sucrose, glucose, and fructose, with sucrose as the major free sugar. Only 5 of the species he investigated contained the free pentoses, arabinose or xylose, and none of them contained detectable quantities of raffinose. Neither free pentoses nor raffinose were detected in leafy spurge.

Glutamic acid, aspartic acid, alanine and gamma-aminobutyric acid were the predominant amino acids in the alcoholic extract. These amino acids are normally found in quantity in other plant

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tissues (8). Other ninhydrin reactive materials present were valine, the leucines, serine, the amides glutamine and asparagine, and small quantities of proline and arginine. Cysteic acid was found following peroxide oxidation. One unknown was found in the alcoholic extract; this migrated about the same as glutamic acid in the phenol and just behind the receding phenol front in the collidine-lutidine solvent.

The sugars glucose, galactose, arabinose and xylose predominated following acid hydrolysis of the alcohol-insoluble residue. Traces of ribose and rhamnose were detected. In addition to the free sugars, a uronic acid was detected.

Following acid hydrolysis of the alcohol-insoluble material 17 ninhydrin reactive spots were found. With 10–20 microliters of the hydrolysate, there were spots corresponding to aspartic acid, glutamic acid, alanine, proline, valine, glycine, serine, lysine, threonine, the leucines, and tyrosine. Histidine was detectable when larger amounts of the material were analyzed. Cysteic acid and methionine sulphone were easily detected following peroxide treatment. Two unknowns were also detected. A material yielding a light blue spot with ninhydrin migrated about the same distance as aspartic acid in phenol and about the distance for tyrosine in the collidine-lutidine solvent. This corresponds roughly with an unknown (No. 18) reported by Steward and Thompson (8) in the alcohol-insoluble portion of the acid hydrolysate of alfalfa, although these workers used a slightly different solvent system. Another unknown material was found in the general region occupied by methionine sulfoxide and gamma-aminobutyric acid.

While these experiments were in progress, it was found that the inhibitor (or inhibitors) could be extracted from spurge with ethanol. Although this might indicate that it is not necessary to consider the alcohol-insoluble fraction as an inhibitor source, there is the possibility that the inhibitor may exist in a bound form in this fraction. Germination experiments made with various concentrations and combinations of the free sugars of spurge have shown that these sugars are not inhibitory. Further studies on the nature of the inhibitor (6) have shown that it may be a non-alkaloidal nitrogen compound. This indicates the advisability of continued studies with amino acids and further efforts to more fully characterize the alcohol-soluble fraction.

LITERATURE CITED

1. BENNETT, E. L., and BONNER, J. Isolation of plant growth inhibitors from *Thamnosa montana*. Amer. Jour. Bot. 40:29–33. 1953.
2. BIDWELL, R. G. S., KROTKOV, G., and REED, G. B. Paper chromatography of sugars in plants. Can. Jour. Bot. 30:291–305. 1952.
3. DENT, C. E. A study of the behaviour of some sixty amino acids and other ninhydrin-reacting substances on phenol-"collidine" filter paper chromatograms, with notes as to the occurrence of some of them in biological fluids. Biochem. Jour. 43:169–180. 1948.
4. EVANARI, M. Germination inhibitors. Bot. Rev. 15:153–194. 1949.

5. HELGESON, E. A., and R. KONZAK. Phytotoxic effects of aqueous extracts of field bindweed and of Canada thistle. A preliminary report. Bimom. Bull. N. Dak. Agr. Expt. Sta. 12:71–76. 1950.
6. LE TOURNEAU, D. The phytotoxic effects of aqueous extracts of leafy spurge. Research Rept., North Central Weed Control Conf., p. 181. 1951.
7. ———, HEGGENESS, H. G., and FAILES, G. D. The effect of aqueous extracts of green plant tissue on germination and seedling growth. Research Rept., North Central Weed Control Conf., p. 161. 1952.
8. STEWARD, F. C., and THOMPSON, J. F. The nitrogenous constituents of plants with special reference to chromatographic methods. Ann. Rev. Plant Physiol. 1:233–264. 1950.

Terminology Committee Report—Weed Society of America[1]

I. Introduction

The Terminology Committee of the Weed Society of America (WSA) has given considerable study to the problems of standardized terminology and the development of common names for chemicals used as herbicides in the field of weed control.

The most acute problem in weed control terminology is the development and adoption of common names for herbicides. This problem is not limited to the field of weed control alone. Every scientific field which envelops the use of agricultural chemicals is confronted with the adoption of common names for chemicals used in agriculture.

The Committee believes that during the discovery, development, and use of herbicides at least two distinct nomenclature phases must be recognized in the selection of a designation to be used for a herbicidal chemical. It is difficult if not impossible to coin common names for herbicidal chemicals until they have reached the commercial development stage. However, the Committee recognizes that an acute need exists for abbreviated designations for herbicidal chemicals while they are in the research and development stages prior to the time they become commercially available.

The objectives and procedures of the Committee have been designed to serve these needs.

II. Objectives of the Committee

A. To serve as a group to develop, standardize, and coordinate the terminology in the field of weed control and the selection of common names for herbicides.

B. To review, revise, and develop standardized terms, abbreviations and definitions used in the field of weed control.

III. Procedures for the Selection of Common Names

A. The coordination of selection of common names for herbicides.

1. The United States Department of Agriculture, in cooperation with the National Agricultural Chemicals Association, and the American Standards Association, has administratively sponsored a committee known as the American Standards Association Sectional Committee on Common Names For Pest Control Chemicals, K62 (ASAK62) which was organized for the purpose of adopting and standardizing common names for chemicals used as herbicides, insecticides, fungicides, rodenticides, nematicides, defoliants, and plant regulators. The American Standards Association (ASA) is also a

[1]The Terminology Committee solicits your suggestions for improving all phases of terminology in the field of weed control. Suggestions should be sent to the chairman, with copies of correspondence directed to each member of the committee.

member of the International Standards Organization (ISO) and the ASA Committee, K62 will work with foreign countries through ISO in its efforts to standardize common names for agricultural chemicals throughout the world.

2. The Weed Society of America is a member of ASAK62. The ASAK62 Committee is composed of scientific societies and all other organizations interested in agricultural chemical nomenclature.

3. The Terminology Committee of WSA is represented on the ASAK62 Committee by the WSA Terminology Committee chairman and two alternates.

4. The Terminology Committee of WSA has participated in all the meetings of ASAK62 relating to herbicide terminology and aided in the development of the procedure for developing common names for pest control chemicals outlined in Appendix A following this report.

B. Function of the Terminology Committee of WSA in the selection of common names for herbicides.

1. The Terminology Committee of WSA will supply copies of the American Standard Procedure For The Acceptance of An American Standard Common Name for a Pest Control Chemical to organizations desiring to sponsor a common name for a herbicide.

2. The Sponsor will then prepare 10 copies of a Statement furnishing the information about the herbicide as outlined in the American Standard Procedure For the Acceptance of An American Standard Common Name for a Pest Control Chemical.

3. The Terminology Committee of WSA will then review the Sponsor's Statement.

4. If the common name proposed by the Sponsor is accepted by the Terminology Committee of WSA, the Committee will recommend that the Sponsor prepare 75 copies of the Statement for submittal to the American Standards Association Sectional Committee on Common Names for Pest Control Chemicals, K62 for final disposition.

IV. CHEMICAL NOMENCLATURE, ABBREVIATIONS, AND DEFINITIONS

A. Suggested terminology guides for authors to follow in preparing for publication in WEEDS or any other publication of WSA.

1. The editorial board will not approve manuscripts for publication in any publication of WSA in which trade names, code names, code numbers, or abbreviated names are used without identifying the active ingredient in the herbicide.

2. The first time a herbicide is mentioned in a manuscript, research report, abstract, or other publication, the full chemical name of the herbicide should be given followed by the accepted common name or designation.

3. The exact derivative of compounds should be indicated. For example: sodium salt of 2,4–D, diethanolamine salt of 2,4–D, isopropyl ester of 2,4–D, butoxyethanol ester of 2,4–D. Avoid the use of:

sodium 2,4–D; 2,4–D sodium; amine 2,4–D; 2,4–D amine; LV ester of 2,4–D; 2,4–D ester.

4. Designations for chemical compounds involving a combination of numbers and letters should be written with capital letters without spacing or periods. The numbers should be separated by commas and the numbers and letters should be separated by a dash (–). For example: 2,4–D, MCPA, 2,3,6–TBA, 4–(2,4–DB), 4–(4–CPB). In writing accepted common names, lower case letters should be used. For example: monuron, diuron, dalapon.

5. Rates of application should always be stated in terms of the acid equivalent when applicable and when not applicable, in terms of the active ingredient.

6. Herbicides for which designations have not been developed should be designated by their full chemical names.

7. The use of the accepted number-letter designations in column 2 of Table 1 will be discontinued as soon as common names are sponsored and adopted.

8. In acknowledging the source of experimental compounds it is suggested this be done in a footnote. For example: "In these studies three compounds, 2,4–D[1], MCPA[1], and 2,4,5–T[1] were applied at three rates of application".

[1]Experimental samples supplied by the ABC Chemical Company, Hometown, Pa.

B. Nomenclature for chemicals used as herbicides.

Table 1. **Chemical designations accepted for use in all WSA publications.**

Chemical name	Designation
2,4-dichlorophenoxyacetic acid	2,4-D
2-methyl-4-chlorophenoxyacetic acid	MCPA
2,4,5-trichlorophenoxyacetic acid	2,4,5-T
3,4-dichlorophenoxyacetic acid	3,4-DA
4-chlorophenoxyacetic acid	4-CPA
2-(2,4-dichlorophenoxy)propionic acid	2-(2,4-DP)
2-(2-methyl-4-chlorophenoxy)propionic acid	2-(MCPP)
2-(2,4,5-trichlorophenoxy)propionic acid	2-(2,4,5-TP)
2-(3,4-dichlorophenoxy)propionic acid	2-(3,4-DP)
2-(4-chlorophenoxy)propionic acid	2-(4-CPP)
4-(2,4-dichlorophenoxy)butyric acid	4-(2,4-DB)
4-(2-methyl-4-chlorophenoxy)butyric acid	4-(MCPB)
4-(2,4,5-trichlorophenoxy)butyric acid	4-(2,4,5-TB)
4-(3,4-dichlorophenoxy)butyric acid	4-(3,4-DB)
4-(4-chlorophenoxy)butyric acid	4-(4-CPB)
sodium 2,4-dichlorophenoxyethyl sulfate	2,4-DES
sodium 2,4,5-trichlorophenoxyethyl sulfate	2,4,5-TES
sodium 2-methyl-4-chlorophenoxyethyl sulfate	MCPES
sodium 2,4-dichlorophenoxyethyl benzoate	2,4-DEB
trichloroacetic acid	TCA
2,2-dichloropropionic acid	dalapon[2] (dăl′-ă-pŏn)
2,2,3-trichloropropionic acid	2,2,3-TPA
dichloral urea	DCU
2-chloro-N,N-diallylacetamide	CDAA
2-chloro-N,N-diethylacetamide	CDEA
isopropyl N-phenylcarbamate	IPC
isopropyl N-(3-chlorophenyl)carbamate	CIPC
sec-butyl N-(3-chlorophenyl)carbamate	BCPC
2-chloroallyl diethyldithiocarbamate	CDEC
3-(phenyl)-1,1-dimethylurea	fenuron[2] (fĕn′-ū-rŏn)
3-(*p*-chlorophenyl)-1,1-dimethylurea	monuron[2] (mŏn′ū-rŏn)
3-(3,4-dichlorophenyl)-1,1-dimethylurea	diuron[2] (dī′-ū-rŏn)
3-(3,4-dichlorophenyl)-1-methyl-1-*n*-butylurea	neburon[2] (nĕb′-ū-rŏn)
pentachlorophenol	PCP

Chemical name	Designation
4,6-dinitro ortho secondary butylphenol	DNBP
4,6-dinitro ortho secondary amylphenol	DNAP
3,5-dinitro ortho cresol	DNC
2,3,6-trichlorobenzoic acid	2,3,6-TBA[3]
2,3,5,6-tetrachlorobenzoic acid	2,3,5,6-TBA[3]
N-1-naphthyl phthalamic acid	NPA
3,6-endoxohexahydrophthallic acid	endothal (en′-dō-thal)
phenyl mercuric acetate	PMA
potassium cyanate	KOCN
hexachloroacetone	HCA
isopropyl xanthic acid	IPX
maleic hydrazide	MH
trichlorobenzenes	XTB
2-chloro-4,6-bis(diethylamino)-S-triazine	CDT
3-amino-1,2,4-triazole	ATA
octochloro cyclohexenone	OCH
ethyl xanthogen disulfide	EXD
monomethyl arsonic acid	MAA
2-(2,4,5-trichlorophenoxy)ethyl 2,2-dichloropropionate	erbon[2] (ĕr′-bŏn)

[2]Common names "tentatively accepted" by the Terminology Committee of W.S.A. Final acceptance of these common names will be delayed until they have been submitted to the Committee by a sponsor and approved by ASA K62 as American Standard names.

[3]These compounds are usually available for use as herbicides as mixed isomers. When possible the isomers should be identified and the source of the experimental chemicals given.

C. Abbreviations of terms used in weed control.

The use of the following abbreviations is recommended and unless otherwise indicated, should be lower case letters without spacing or periods.

Abbreviations	*Definitions*
ahg	acid equivalent per 100 gallons
A	acre
bu	bushel or bushels
diam	diameter
ft	foot or feet
fpm	feet per minute
gal	gallon or gallons
in	inch or inches
mph	miles per hour
ppmw	parts per million by weight
ppmv	parts per million by volume
pt	pint or pints
lb	pound or pounds
psi	pounds per square inch
qt	quart or quarts
gal/A, oz/A	rate per acre
rpm	revolutions per minute
sq	square
wt	weight
gpa	gallons per acre
gph	gallons per hour
oz	ounce or ounces
ht	height
mi	mile or miles
ml	milliliter
L	liter
gpm	gallons per minute
cfs	cubic feet per second
mm	millimeter or millimeters

Abbreviations	*Definitions*
mp	melting point
ppt	precipitate
sp. gr.	specific gravity
tech	technical
temp	temperature
WSA	Weed Society of America
SWC	Southern Weed Conference
NEWCC	Northeastern Weed Control Conference
NCWCC	North Central Weed Control Conference
WWCC	Western Weed Control Conference

D. Definitions of terms used in weed control.

Term	*Definition*

Annual. A plant that completes it life cycle from seed in one year.

Band application. An application of spray or dust to a continuous restricted area such as in or along a crop row rather than over the entire field area.

Basal treatment. A woody plant treatment applied to the stems of plants at and just above the ground line.

Bed. (1) A narrow flat-topped ridge on which crops are grown with a furrow on each side for drainage of excess water. (2) An area in which seedlings or sprouts are grown before transplanting.

Bed-up. To built up beds or ridges with a tillage implement.

Biennial. A plant that completes its life cycle in two years. The first year it produces leaves and stores food. The second year it produces fruits and seeds.

Broadcast application. An application of spray or dust over an entire area rather than in a band only on rows, beds, or middles.

Blind cultivation. Cultivating before a seeded or planted crop emerges.

Brush control. Control of woody plants.

Carrier. The liquid or solid material added to a chemical or formulation to facilitate its field use.

Compatible. Two compounds are said to be compatible when they can be mixed without affecting each other's properties.

Concentration. Refers to amount of active material in a given volume of diluent. Recommendations and specifications for concentration of herbicides should be on the basis of pounds per unit volume of diluent.

Contact herbicide. A herbicide that kills primarily by contact with plant tissue rather than as a result of translocation.

Defoliator or Defoliant. A compound which causes the leaves, or foliage, to drop from the plant.

Diluent. Any liquid or solid material serving to dilute an active ingredient in the preparation of a formulation.

Directed Application. An application of spray of dust to a restricted area such as a row, or bed at base of plants.

Duckfoot cultivator. A field cultivator equipped with small sweep shovels.

Emulsifying agent. A surface active material which facilitates the suspension of one liquid in another.

Emulsion. The suspension of one liquid as minute globules in another liquid; for example, oil dispersed in water.

Term	*Definition*

Epinasty. The twisting or curling of leaves and stems caused by uneven growth of cells. (A state of growing in leaves in which the upper surface grows faster than the lower surface and thus causes the leaf edges to curve down.)

Growth stages of cereal crops. (1) Tillering stage—when a plant produces additional shoots from a single crown. (2) Jointing stage—when the internodes of the stem are elongating. (3) Boot stage—when the seed head of a plant begins to emerge from the sheath.

Herbaceous. A succulent plant that does not develop woody tissue.

Herbicide. A phytotoxic chemical used for killing or inhibiting the growth of plants.

Miscible. Two or more liquids which, when mixed together, form a uniform mix.

Perennial. A plant that lives for more than two years.

Noxious weed. A weed arbitrarily defined by law as being especially undesirable, troublesome, and difficult to control. Definition of the term "noxious weed" will vary according to legal interpretations.

Phytotoxic. A substance toxic to plants.

Post-emergence Treatment. Any treatment made after the crop plants emerge.

Pre-emergence Treatment. Any treatment made after a crop is planted but before it emerges. (1) *Contact pre-emergence.* An application made after weed emergence. (2) *Residual pre-emergence.* An application which kills weeds as the seed germinates or as they emerge either before or after the crop has emerged.

Pre-planting treatment. Any treatment made before the crop is planted.

Rate and Dosage. These terms are synonymous. "Rate" is the preferred term. Rate usually refers to the amount of active ingredient material (such as 2,4–D acid equivalent) applied to a unit area (such as one acre) regardless of percentage of chemical in the carrier.

Selective Herbicide. A compound that is more toxic to one plant than to another.

Soil Sterilant. A herbicide that prevents the growth of plants when applied to the soil. Soil sterilization effects may be temporary or relatively permanent.

Spray Drift. The movement of airborne spray particles from the intended contact area to adjacent areas.

Surfactant. A material which facilitates, and accentuates the emulsifying, dispersing, spreading, wetting, and other surface-modifying properties of herbicide formulations.

Suspension. A system consisting of very finely divided solid particles dispersed in a solid, liquid or gas.

Synergism. Cooperative action of different agencies such that the total effect is greater than the sum of the two effects working independently.

Systemic Herbicide. A phytotoxic compound which is translocated within the plant.

Vapor Drift. The movement of herbicidal vapors from the area of application to adjacent areas.

Volatile. A compound is said to be volatile when it evaporates, or vaporizes (changes from a liquid to a gas) at ordinary temperatures on exposure to the air.

Wetting Agent. A compound which when added to a spray solution causes it to contact plant surfaces more thoroughly.

Weed. A plant growing where it is not desired.

Term	*Definition*
Crop.	A plant growing where it is desired.
Weed eradication.	The complete elimination of all live plants, plant parts, and seeds of a weed infestation from an area.
Weed control.	The process of inhibiting weed growth and limiting weed infestations so that crops can be grown profitably or other operations can be conducted efficiently.

Prepared by the Terminology Committee, Feb. 1, 1956.

R. Behrens
R. D. Sweet
L. G. Holm
C. I. Seely
W. C. Shaw, Chairman

Appendix A

American Standard Procedure for the Acceptance of an American Standard Common Name for a Pest Control Chemical.[4]

1. Scope and Purpose

1.1 The following procedure has been developed for use in securing approval as an American Standard Common Name for a pest control chemical by the American Standards Association, Incorporated, (ASA). It is intended to make possible the adoption of common names readily acceptable and usable by all interested groups, while guarding against confusion with existing common or proprietary names and against improper use in the future.

1.2 In general the procedure consists of:

1.2.1 Tentative selection of a common name by the Sponsor.

1.2.2 Preparation by the Sponsor of a Statement, proposing the common name, and giving such properties and other information as may be required.

1.2.3 Submission of the Statement to the Committee.

1.2.4 Review and action by the Committee.

1.2.5 Adoption of the common name and release of the American Standard by the ASA.

2. Definitions

2.1 For purposes of this standard, the following terms are intended to have the meaning indicated.

2.2 American Standard. The designation given to a standard that has been approved by the ASA Standards Council or its designated agency.

2.3 Common Name. A coined name which applies to the 100% pure pest control chemical and which is available for unrestricted use.

[4]American Standard K62.1–1956 was approved by the American Standards Association on February 28, 1956. This procedure is reprinted with the permission of the American Standards Association. Copies of the procedure may be purchased from the American Standards Association, 70 East Forty-fifth Street, New York 17, N. Y.

2.4 Pest Control Chemical. A chemical having potential use in pesticides, including insecticides, fungicides, rodenticides, herbicides, and nematicides, and also defoliants and plant regulators.

2.5 ASA. These letters serve as the abbreviation for the name, American Standards Association, Incorporated, 70 East 45th Street, New York 17, New York.

2.6 Sponsor. The one initially requesting acceptance of a Common Name. It may be the actual manufacturer of the product, or a formulator or an organization interested in the product.

2.7 Statement. The proposed Common Name and data submitted by a Sponsor to the Committee, when requesting acceptance of a Common Name for a Pest Control Chemical.

2.8 Committee. The ASA Sectional Committee on Common Names for Pest Control Chemicals, K62.

2.9 Administrative Sponsor. The organization so designated by ASA to be responsible for the organization and proper functioning of the Committee in conformance with the ASA Constitution, Bylaws and Procedure, (PM 125).

3. Selection of a Common Name

3.1 Common Names will be considered for Pest Control Chemicals.

3.2 Requests for acceptance of Common Names will be considered only for those products which have reached a stage of development which is considered likely to result in commercial distribution. The Committee reserves the right to reject applications concerning a product or products which, in the opinion of the Committee members, are not likely to be introduced into commerce.

3.3 A Common Name shall be preferably short and need have no chemical name or nature of the product. Commonly accepted chemical prefixes or suffixes shall be avoided as far as possible, but if used, such use shall in no way conflict with the standards of nomenclature of the American Chemical Society. (See list of nomenclature pamphlets in *Chemical and Engineering News* 31, 2803 (1953)).[5] The name should not be similar phonetically or in spelling to systematically formed names or to trade or Common Names of other commercial chemicals even though such chemicals may not be used in pest control. Proposed Common Names consisting of initials or numbers or a combination of initials and numbers will not be considered.

3.4 Names for simple chemical salts and esters should be coined so as to apply only to the parent chemical. (For example, if the parent substance is given the name Warfarin and is acidic in nature, its sodium salt would be designated Warfarin sodium). Exceptions to this requirement may be permitted when, as judged on the merits of each case, at least one of the following circumstances prevails: (1) the compound (derivative) significantly alters the actions or scope of the parent chemical, (2) the usual chemical terminology is too lengthy or unwieldy for practical usage, or (3)

[5]Reprints of lists and pamphlets available from Chemical Abstracts, Ohio State University, Columbus 10, Ohio.

the introduction of other salts, esters of the parent chemical is not likely.

3.5 A proposed Common Name will be considered for acceptance only when the Sponsor certifies that a search has been conducted and findings are submitted to verify the absence of conflicts with existing domestic trademarks or names for other chemicals or products. Should the proposed Common Name itself be trademarked or be in apparent conflict with any domestic trade-mark or trade name, the Sponsor shall submit to the Committee a written statement from the trade-mark owner releasing the proposed Common Name for unrestricted use. (See 4.2.11)

4. Preparation of Statement

4.1 A Sponsor, having selected a proposed Common Name pursuant to Section 3, shall prepare the Statement for submission to the Committee and patterned after that shown in Appendix A.

4.2 The Statement shall include:

4.2.1 The name and address of the Sponsor.

4.2.2 The basis of the Sponsor's interest in the product.

4.2.3 The proposed Common Name and its pronounciation.

4.2.4 Its classification, i.e., fungicidal chemical, herbicidal chemical, etc.

4.2.5 Its systematic name and chemical structure when known.

4.2.6 The purity of the technical or the commercial grade of product to be offered in terms of percentage of the parent chemical, and the percentage of associated compounds or contaminants normally encountered in the commercially offered product.

4.2.7 All trade-marks, trade names, coined names and synomyms associated with the products by the industry and in the field of use.

4.2.8 The physical and chemical properties of the pure and technical grades of the chemical as far as can be reasonably determined.

4.2.9 Information clearly indicating the product to be a Pest Control Chemical.

4.2.10 Pertinent findings of the search verifying the absence of conflicts with existing trade-marks or names for other chemicals or products.

4.2.11 The following clause: "The undersigned agrees to release and permit the use of the name '————' (the proposed common name) for use with respect to any product, whether or not manufactured or formulated by the undersigned, which contains a pest control chemical conforming to the description of the pest control chemical specified by ASA in an American Standard adopted and made public pursuant to this Statement."

4.2.12 The written signature and title of the duly authorized representative of the Sponsor.

5. Procedure

5.1 The Sponsor shall submit the signed original and 75 copies of this Statement to:

J. A. Noone, Secretary
ASA Sectional Committee, K 62
National Agricultural Chemicals Association
Associations Building
1145 19th Street, N. W.
Washington 6, D. C.

5.2 The Secretary shall circulate to all members of the Committee for action copies of the Statement and a proposed American Standard including the Common Name together with the name of the chemical and information on its major field of use and physical and chemical properties. If the Sponsor is not the basic manufacturer of the chemical, a copy of the Statement shall be furnished to the manufacturer who shall have the opportunity to approve or object to the proposed Common Name.

5.3 Action by the Committee will take the form of:

5.3.1 A decision to accept the proposed American Standard and to recommend its approval as the American Standard Common Name for the specified pest control chemical.

5.3.2 A decision to withhold final Committee action until requested additioinal data are submitted by the Sponsor.

5.3.3 A decision to reject the request for acceptance.

5.4 The Secretary of the Committee shall:

5.4.1 Notify the Sponsor of the Committee action taken and the basis thereof.

5.4.2 Transmit the Committee recommendations for acceptance to the Administrative Sponsor for transmittal with its recommendations to the ASA.

5.5 Action by ASA on the recommendations of the Administrative Sponsor will be taken pursuant to the Constitution, By-laws and Procedure of the American Standards Association, Inc. (PM 125).

5.6 Upon approval of the American Standard by ASA, it will be made public through publication by the ASA and/or by such organizations as it may authorize to do so. The published American Standard shall include the following clause: Neither ASA nor its committee guarantees or assumes any responsibility that use of this name in connection with this or any other chemical or product will not infringe on or conflict with any existing proprietary name, trade mark or trade name. Approval as an American Standard Common Name constitutes reccognition by ASA that a consensus exists within a representative committee, operating under ASA procedure and basing its recommendation on data submitted by a Sponsor, favoring consideration of the use of the name to designate the pest control chemical described herein by all interested persons. The information concerning the chemical and physical properties of the chemical is not a part of the standard but is provided solely as an aid to identification, and ASA does not guarantee its accuracy.

News and Notes

Mr. Harold Kerr has been appointed as Agent (Research Agronomist) by the Field Crops Research Branch, USDA, to assist in weed investigations at Columbia, Missouri.

F. D. Keim died in Washington, D. C. on March 7, 1956. He was formerly Chmn. of the Agronomy Dept., Univ. of Nebraska, and a charter member of the North Central Weed Control Conference. Dr. Keim was instrumental in initiating cooperative research in bindweed control in 1935 between the USDA and various states.

W. B. Ennis, Jr., of the Weed Investigations Section, USDA, has been transferred to the Plant Industry Station, Beltsville, Maryland. He was formerly stationed at State College, Mississippi.

Warren H. Zick received his Ph.D. degree from the Univ. of Wisconsin in January, 1956. He is now employed as Asst. Director of Agricultural Research and Development, Pacific Coast Borax Co., Los Angeles, California.

L. L. Jansen, Weed Investigations Section, USDA, was transferred from Logan, Utah, to the Plant Industry Station, Beltsville, Maryland in March, 1956.

Weeds of the Northeast is the title of Delaware Agri. Exp. Sta. Field Manual No. 1, released in January, 1956. This identification guide uses basal-leaf characteristics rather than the usual flower and seed characters. The publication was accepted by the Northeastern Regional Weed Control Technical Committee as its official weed identification guide for the northeastern states. The manual, which describes 346 weeds, is available from the Univ. of Delaware Agri. Exp. Sta., Newark, Del., at $0.75 per copy.

W. R. Furtick, Farm Crops Dept., Oregon State College, made an extensive tour of the United States early in 1956. He visited weed workers at a number of state institutions, research organizations and commercial concerns.

An Aerial Applicators Meeting was held on March 13 and 14, 1956, at Lincoln, Nebraska, to discuss problems related to the aerial application of herbicides and insecticides.

The officers and meeting places for the various weed conferences for the coming year are as follows:

Southern Weed Conference

President—W. B. Albert, Botany Dept., Clemson College, Clemson, South Carolina.

Vice-president—E. G. Rodgers, Dept. of Agronomy, Univ. of Florida, Gainesville, Florida.

Sec.-Treas.—W. K. Porter, Jr., Dept. of Plant Pathology, Louisiana State University, Baton Rouge, Louisiana.

Next Meeting—January 23, 24 and 25, 1957, at the Bon Air Hotel, Augusta, Georgia.

Northeastern Weed Control Conference

President—L. L. Danielson, Virginia Truck Exp. Sta., P. O. Box 2160, Norfolk, Virginia.
Vice-president—C. L. Hovey, Eastern States Farmers' Exchange, West Springfield, Mass.
Secretary—R. J. Aldrich, Farm Crops Dept., Rutgers University, New Brunswick, New Jersey.
Treasurer—D. A. Schallock, Farm Crops Dept., Rutgers University, New Brunswick, New Jersey.
Next meeting—January 9, 10 and 11, 1957, Hotel New Yorker, New York City.

Western Weed Control Conference

President—Henry Wolfe, Dept. of Agronomy, Washington State College, Pullman, Washington.
Vice-president—Dick Fosse, American Chemical Paint Co., Denver, Colo.
Sec.-Treas.—W. R. Furtick, Farm Crops Dept., Oregon State College, Corvallis, Oregon.
Next meeting—February, 1958, at Spokane, Washington.

North Central Weed Control Conference

President—E. A. Helgeson, Dept. of Botany, North Dakota State College, Fargo, North Dakota.
Vice-president—F. W. Slife, Dept. of Agronomy, Univ. of Illinois, Urbana, Illinois.
Sec.-Treas.—D. W. Lambert, Nebraska State Dept. of Agriculture, Lincoln, Nebraska.
Next meeting—December 11, 12 and 13, 1956, at the Sherman Hotel, Chicago, Illinois.

Sustaining Members

American Chemical Paint Company, Ambler, Pennsylvania
American Cyanamid Company, New York, New York
American Smelting and Refining Company, So. Plainfield, New Jersey
Association of American Railroads, Chicago, Illinois
John Bean Division, Food Machinery & Chemical Corp., Lansing, Michigan
Carbide and Carbon Chemicals Company, New York, New York
Chipman Chemical Company, Inc., Bound Brook, New Jersey
The Dow Chemical Company, Midland, Michigan
E. I. duPont de Nemours & Co., Inc., Wilmington, Delaware
The Engine Parts Manufacturing Company, Cleveland, Ohio
G.L.F. Soil Building Service, Ithaca, New York
Hercules Powder Company, Wilmington, Delaware
Monsanto Chemical Company, St. Louis, Missouri
National Aluminate Corp., Chicago, Illinois
Oberdorfer Foundries, Inc., Syracuse, New York
Olin Mathieson Chemical Company, Baltimore, Maryland
Penn Line Service, Inc., Scottdale, Pennsylvania
Pittsburgh Coke & Chemical Company, Pittsburgh, Pennsylvania
O. M. Scott and Sons Company, Marysville, Ohio
Spraying Systems Company, Bellwood, Illinois
Standard Agricultural Chemicals, Inc., Hoboken, New Jersey
Swift and Company (Plant Food Division), Chicago, Illinois

BIBLIOGRAPHY OF WEED INVESTIGATIONS
for
January through December 1955

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Prepared By
UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service
Field Crops Research Branch

This bibliography of current literature on weeds and their control is issued as a service to those engaged in weed research in the United States and other countries. In issuing this bibliography the Field Crops Research Branch, Agricultural Research Service, U.S.D.A. does not assume responsibility for the subject matter cited.

Beltsville, Maryland

I. Economic Aspects and General Weed Problems

1. Anderson, E. G. Co-operation between research, industry, extension and regulatory groups, in the attack on weed problems in Canada. No. Cent. Weed Control Conf. Proc. 11:20–21. 1954.
2. ————. Is chemical weed control worthwhile? Family Herald & Wk. Star 85(36):3. Sept. 8, 1955.
3. Authosserre, M. La destruction des plantes nuisibles dans les alpages. Fed. Franc. d'Econ. Alpestre. B. (n.S.)4:41–43. 1953/54.
4. Ball, W. S. What weeds cost in relation to quarantine and seed regulations. Calif. Weed Conf. Proc. 7:1–3. 1955.
5. Baranek, P. P. What weeds cost in relation to irrigation itself. Calif. Weed Conf. Proc. 7:11–13. 1955.
6. Benson, D. S. Public relations in ragweed control. Noeast. Weed Control Conf. Proc. 8:509–515. 1954.
7. Berry, T. F. The way to win the war on weeds. Grange News 49(3):3. Feb. 11, 1955.
8. Bohmont, D. W. Weed control in Wyoming. Wyo. Agr. Expt. Sta. C. 59, 11 p. Apr. 1955.
9. Bonilla, R. A. Notas sobre el uso de yerbicidas (2,4–D). Rev. del Cafe 10(5):35–36,41. Jan. 1955.
10. Bowman, J. J. Weed control during 1953 in Ohio. Noeast. Weed Control Conf. Proc. 8:505.507. 1954.
11. Bradford, M. Weed control recommendations. Agr. Merchant 35:223–224. May 1955.
12. Britton, J. W. The responsibilities of the chemical industry in the development of a weed control program. So. Weed Conf. Proc. 8:20–24. 1955.
13. Bylterud, A. New progress in weed control. (In Norwegian.) Norsk Landbr. 21:30–31. Jan. 21, 1955.
14. California Weed Conference. Proceedings, seventh annual, January 26 and 27, 1955.
15. Canada. National Weed Committee. Eastern Sect. Proceedings of the eighth meeting, November 1, 2, 3, 1954. Ottawa, 1955. 157 p.
16. ————. Herbicide Committee, Report, 1955. Canada. Natl. Weed Comt. East. Sect. Proc. 8:131–154, 1954.
17. Cartier, R. D. Les herbicides. B. des Agr. 37(12):16,88–89. Feb. 1955.
18. Chipman Chemical Engineering Co. You can't argue with weeds. You've got to kill them! Bound Brook, N. J., 1954. 34 p.
19. Ciferri, R. Guide to selective hormone herbicides. II. (In Italian.) Riso 3(8):5–7. Aug. 1954.
20. Clouston, D., and Scragg, E. B. Spraying for weed control. Scot. Agr. 34:226. Spring 1955.
21. Colvard, D. W. The role of State experiment stations and extension services in developing a weed control program. So. Weed Conf. Proc. 8:9–13. 1955.
22. Cox, W. T. B. Wait, and then weed. Farmers Wk. (London) 42(12):101, 104. Mar. 25, 1955.
23. Datta, S. K., and Banerjee, G. Chemical control of some weeds of Darjeeling. Sci. & Cult. 20:191–193. Oct. 1954.
24. Dearborn, C. H. Chemical weed killers and their use. Alaska. U. Ext. B. 610, 20 p. May 1955.
25. Denmark. Statens Ukrudtsforsog. The Danish Institute for Weed Research 1953. (In Danish.) Tidsskr. f. Planteavl 58:177–184. 1954.
26. Dingwall, A. R. Weed control of South Island hill country. Lincoln Col. Farmers' Conf. Proc. 1954:84–93.
27. Dreessen, J. USDA weed plots. Natl. Agr. Chem. Assoc. News & Pesticide Rev. 12(6):5–6. July/Aug. 1954.
28. Dunham, R. S., Hanson, H. L., Nylund, R. E. and Jensen, E. H. Cultural and chemical weed control in Minnesota, 1955. Minn. U. Agr. Ext. Folder 191, 32 p. Jan. 1955.
29. Fast, M. The Council of State Governments and weed control problems. No. Cent. Weed Control Conf. Proc. 11:19–20. 1954.
30. Fryer, J. D. Some topical aspects of chemical weed control in Great Britain. Inst. Corn & Agr. Merchants. J. 5:16–21. Spring 1955.

31. GATECLIFF, M. Weed killers. Women's Farm & Gard. Assoc. Year Book 1954:27–32.
32. GODED Y MUR, A. Herbicidas. Zaragoza. Inst. Munic. de Hig. An. 3(2):1–2. Sept. 1954.
33. GORSLINE, G. W. Gone with the weeds. Susquehanna-Wyo. Farm & Home News 8(5):1,15. June 1955.
34. GUDNASON, A. Weedkillers. (In Icelandic.) Freyr 51:54–47. Feb. 1954.
35. GUSTAFSSON, H. Bekampa ograset (Control weeds). Hushsallsk. Forbund. Smaskr. 10, 16 p. 1955.
36. HAMPSON, C. P. Economics of weed control. Agr. Merchant 35:221–223. May 1955.
37. HANSCHELL, D. M. Weed control. Agr. Soc. Trinidad & Tobago. J. 54:423–425, 427–429. Dec. 1954.
38. HARVEY, W. A. Responsibilities of an extension weed specialist. Weeds 3:45–48. Jan. 1954.
39. HOFSTEN, C. G. VON. Fall spraying of dormant weeds. (In Swedish.) Lantmannen 38:883–884. Oct. 2, 1954.
40. HULME, S. A. Hormone type weedicides. Farming So. Africa 30:215–219. Apr. 1955.
41. IRVINE, M. B. Chemical weed control. West Colo. Hort. Soc. Proc. 12:31, 33, 35, 37, 39, 41, 43, 45–51. 1955.
42. IVANOV, V. P. Sornye rasteniia i mery bor'by s nimi (Weeds and measures for controlling them). Moskva, Akademiia Nauk SSSR, 1955. 172 p.
43. JETNE, M. Weeds. (In Norwegian.) Landrukstidende 61:358–359. May 11, 1955.
44. JONES, L. G. What weeds cost in irrigated crops. Calif. Weed Conf. Proc. 7:13–15. 1955.
45. ————. What weeds cost in irrigated crops. Calif. Farmer, South Ed. 202:693–694. June 25, 1955.
46. JUILLET, A. A propos des applications de l'acide 2,4-dichlorophenoxy-acetique. Cong. Internatl. de Phytopharm. (Compt. Rend.) 3(2):730–731. 1952, pub. 1954.
47. KASAHARA, Y. Studies on the weeds of arable land in Japan, with special reference to kinds of harmful weeds, their geographic distribution, abundance, life-length, origin and history. Okayama U. Ohara Inst. f. Landwirt. Biol. Ber. 10:72–109. Ref. 1954.
48. KEPNER, P. V. Extension work with respect to weed control. Weeds 3:49–54. Jan. 1954.
49. KINGSMILL, J. Chemical weed control. Essex Farmers' J. 34(3):43–44. May 1955.
50. KLINGMAN, G. C. Liquid nitrogen doubles as weed killer. Res. & Farming (N.C. Sta.) 12(3/4):3,15. Winter/Spring 1954.
51. KNIGHT, L. J. It is easier to beat the weeds in New Zealand. Grower (London) 43:891. April 9, 1955.
52. KNOWLES, G. My twenty two years with weeds. Canada Natl. Weed Comt. East. Sect. Proc. 8:4–9, 1954, pub. 1955.
53. KOLEV, I., and KUDREV, T. Study of effect of 2,4–D in weed control. (In Bulgarian) Bulgar. Akad. na Nauk. Inst. za Rastenievud. Izv. 2:121–160. Ref. 1954.
54. KONG DE BROTOS, L. Aplicacion de herbicidas. Res. 23:30332, 30334. Aug. 5, 1955.
55. KOTT, S. A. Sornye rasteniia i mery bor'by s nimi (Weeds and measures for controlling them). Ed. 2. Moskva, Gosudarstvennoe Izdatel'stvo Sel'skokhoziaistvennoi Literatury, 1955. 383 p.
56. KUHN, A. O. The relationship between research and extension in weed control. Noeast. Weed Control Conf. Proc. 8:33–38. 1954.
57. LAPENSEE, L. La destruction des mauvaises herbes messiales: les arrosages au 2, 4–D. Rev. d'Oka 29:33–47,53. Ref. Mar./Apr. 1955.
58. LEE, O. C. Trends in teaching weed control. Weeds 3:136–138. Apr. 1954.
59. LING, L. Hormonas herbicidas. Balearic Isl. Diputacion Prov. B. de Agr. 127:11–14. (Cont.) Apr. 1955.

60. LOVVORN, R. L. Let chemicals kill weeds and brush. Prog. Farmer, Tex. Ed. 70(3):60–61. Mar. 1955.
61. MAJOR, J. What weeds cost on ranges. Calif. Weed Conf. Proc. 7:6–8. 1955.
62. MANN, D. Will weeds be with us always? Kans. Farmer 92(9):6,27. May 7, 1955.
63. MEADLY, G. R. W. Making full use of selective herbicides. Wesfarmers News 3(13):12–13. Mar. 31, 1955.
64. MISSISSIPPI. AGRICULTURAL EXPERIMENT STATION. Chemical weed control recommendations. Miss. Farm Res. 18(3):3–7. Mar. 1955.
65. ———. Chemical weed control recommendations. Miss. Agr. Expt. Sta. C. 195, 26 p. Mar. 1955.
66. MITCHELL, F. L. Weed control on the farm. No. Cent. Weed Control Conf. Proc. 11:133–134. 1954.
67. MUZIK, T. J. Weed control in Puerto Rico. Advn. Chem. Ser. 13:85–95. Ref. Mar. 1955.
68. NARAYANAN, T. R. Recent advances in agriculture with special reference to weed control. Madras Agr. J. 41:310–313. Sept. 1954.
69. NEFF, A. L. Practical experience with herbicides. Fla. State Hort. Soc. Proc. 67:107–109. 1954.
70. NETHERLANDS. PLANTENZIEKTENKUNDIGE DIENST. Bericht over onkruidbestrijdingsmiddelen (Report on herbicides). Netherlands. Plantenziektenk. Dienst. Ber. 1118, 8 p. Feb. 1955.
71. NISSEN, G. Chemical weed control. (In Danish.) Jydsk Landbr. 37:286–288. Apr. 28, 1955.
72. NORTH CENTRAL WEED CONTROL CONFERENCE. Research report, eleventh annual conference, Fargo, North Dakota, December 7, 8 and 9, 1954. n.p., 1954.
73. NORTH CENTRAL WEED CONTROL CONFERENCE. COMMITTEE ON TERMINOLOGY. Recommendations of the Committee on Terminology. No. Cent. Weed Control Conf. Proc. 11:149–151. 1954.
74. NORTH CENTRAL WEED CONTROL CONFERENCE. RESEARCH COMMITTEE. Recommendations of the Research Committee of the N.C.W.C.C. No. Cent. Weed Control Conf. Proc. 11:135–149. 1954.
75. NORTHEASTERN WEED CONTROL CONFERENCE. Proceedings of the eighth annual meeting, Hotel New Yorker, New York City, January 5, 6, 7, 1954. n.p., 1954. 546 p., and sup.
76. ———. Proceedings of the ninth annual meeting, January 5, 6, 7, 1955. n.p., 1955. 562 p., and sup.
77. ONTARIO. ADVISORY COMMITTEE ON HERBICIDES. Save time! Labour! Money! Follow the 1955 guide to chemical weed control; field crops. Ontario Dept. Agr. Ext. C. 75A, 16 p.-folder. June 1955.
78. ———. Save time! Labour! Money! Follow the 1955 guide to chemical weed control; horticultural crops. Ontario. Dept. Agr. Ext. C. 75B, 16 p.-folder. June 1955.
79. ——— Save time! Labour! Money! Follow the 1955 guide to chemical weed control; roadsides and waste places. Ontario. Dept. Agr. Ext. C. 75C, 16 p.-folder. June 1955.
80. PARKER, M. W. The weed research program of the U. S. Department of Agriculture. No. Cent. Weed Control Conf. Proc. 11:1–5. 1954.
81. ———. Present status and future plans of USDA weed control research program. Natl. Agr. Chem. Assoc. News & Pesticide Rev. 13(5):10–12. May/June 1955.
82. PETERSEN, H. I. Spraying plan 1955. (In Danish.) Tolvmandsbladet 27:153. May 1955.
83. PRICE, L. N. A county highway weed-control program. Pub. Works 86(6):156,158,160. June 1955.
84. PROBYN, E. H. 1954 British Weed Control Conference. Empire Forestry Rev. 34:61–63. Mar. 1955.
85. RADEMACHER, B. British Weed Control Conference in Harrogate (2.–4. 11. 1954). (Abs.) Angew. Chem. 67:310–311. June 7, 1955.
86. RIPLEY, P. O. Weed control in western Canada. Empire J. Expt. Agr. 22:261–266. Oct. 1954.

87. ROSEWORTHY AGRICULTURAL COLLEGE. Australia's weed problems; weed-control conference. Rur. Res. C.S.I.R.O. 11:16–19. Mar. 1955.
88. RUSSCHEN, J. Chemical weed control in 1954. (In Dutch.) Netherlands. Dir. van de Landb. Verslag van het Landbk. Onderz. in Noordelijk-Groningen 1954:79–83.
89. SANDERSON, C. Essentials of a county weed control program. No. Cent. Weed Control Conf. Proc. 11:21–24. 1954.
90. SCHALLOCK, D. A. Visual aids to a weed control program. Noeast. Weed Control. Conf. Proc. 9:85. 1955.
91. SENSKE, W. M. Industrial and home weed control. Pest Control 23(5): 36–37. May 1955.
92. SHAW, W. C. Recent advances in weed control. (Abs.) Nat. Agr. Chem. Assoc. News & Pesticide Rev. 13(2):8–10. Nov./Dec. 1954.
93. ————. Weed control—the challenge of a new scientific discipline. So. Weed Conf. Proc. 8:1–8. 1955.
94. SMITH, N. J. Experiences with an extension program for chemical weed control in Madison County, New York. Noeast. Weed Control Conf. Proc. 8:45–49. 1954.
95. SOKOLOV, N. P. Using herbicides in weed control. (In Russian) Sovkhoz. Proizvodstv 2:88–90. Feb. 1955.
96. SOKOLOV, N., and GORBUNOV, S. Weed control on virgin soils and waste lands in Northern Kazakhstan. (In Russian) Zemledelie 3(6):47–52. June 1955.
97. SOUTHERN WEED CONFERENCE. Proceedings, eighth annual meeting, January 17, 18, 19, 1955. n.p., 1955. 476 p.
98. SPRAGUE, R. K. Promotional activities in noxious weed control during 1953 in the State of Connecticut. Noeast. Weed Control Conf. Proc. 8:503–504. 1954.
99. STAIRS, H. F. Weed control activities in New Brunswick, 1954. Canada. Natl. Weed Comt. East. Sect. Proc. 8:18–21. 1954 pub. 1955.
100. ————, and ARGUE, C. W. Ragweed report for New Brunswick, 1954. Canada Natl. Weed Comt. East. Sect. Proc. 8:75. 1954, pub. 1955.
101. STARKER, C. Dusting, spraying conference. Agr. Chem. 9(12):39–41, 111, 113. Dec. 1954.
102. STEINEN, O. P. Alanap. Calif. Weed Conf. Proc. 7:40–43. 1955.
103. SUGGITT, J. W. *Brush control acreage sprayed in Canada, 1953. Canada. Natl. Weed Comt. East. Sect. Proc. 8:54–56. 1954, pub. 1955.
104. SYLWESTER, E. P. Sponsoring an extension weed control program. Noeast. Weed Control Conf. Proc. 8:39–44. 1954.
105. ————. Use of chemicals in a practical weed control program. No. Cent. Weed Control Conf. Proc. 11:125–126. 1954.
106. ————, GUNDERSON, H., and SHURTLEFF, M. C. Spraying calendar for weeds and brush. Hoard's Dairyman 100:404–405. Apr. 25, 1955.
107. TEMPANY, SIR H. Problems and progress of weed control. Agr. Soc. Trinidad & Tobago. J. 54:431, 433–434. Dec. 1954.
108. THE ONLY GOOD WEED IS A DEAD WEED. Co. Agent & Vo-Ag Teacher 11(7):19–22. July 1955.
109. THOMPSON, W. R. Weed control. Miss. State Col. Ext. P. 304, 8 p.-folder. June 1955.
110. TIBERG, S. Combine harvesting of weeds. (In Swedish) Lantmannen 39:618–619. July 2, 1955.
111. TUPLIN, I. L. Provincial report on weed control, Prince Edward Island, 1954. Canada. Natl. Weed Comt. East. Sect. Proc. 8:22–24. 1954, pub. 1955.
112. VENTURA COUNTY, CALIFORNIA. Agricultural Commissioner. Chemical control of weeds, brush, and trees in Ventura County. Ventura, 1954. 10 p.
113. VERMONT UNIVERSITY. COLLEGE OF AGRICULTURE. EXTENSION SERV. Vermont recommendations for chemical weed control, 1954. Burlington, 1954. 1 p.
114. ————. Vermont weed control 1955. Vt. Agr. Col. Ext. Brieflet 949, 10 p. 1955.

115. WALSTER, H. L. The North Dakota Agricultural College battles weeds. No. Cent. Weed Control Conf. Proc. 11:29–34. 1954.
116. WIDDIFIELD, R. B. A statewide extension program in weed control. Weeds 3:188–191. Apr. 1954.
117. WILLARD, C. J. Weed control: past, present, prospects. Agron. J. 46:481–484. Nov. 1954.
118. ————. Weed control—past, present, prospects. What's New Crops & Soils 7(3):7–9. Dec. 1954.
119. ————. Weed control: past, present, prospects. Noeast. Weed Control Conf. Proc. 9:69–73. 1955.
120. WILLIAMS, A. T. Pre-emergence spraying has many advantages. East. States Coop. 31(3):12–13. Mar. 1955.
121. WILLITS, N. A., and ROBERTSON, L. Michigan State in FOA program. Agr. Chem. 10(3):47–48, 131. Mar. 1955.
122. YOUNG, A. W. J. Weed control. Countryman (Burford) 51:118–121. Spring 1955.
123. ZEDLER, R. J. Weed prevention; a new concept of weed control. Mkt. Growers J. 84 (7):24. July 1955.

II. BOTANY OF WEEDS

1. BASSETT, I. J. The procedure in analyzing ragweed pollen slides. Canada. Natl. Weed Comt. East. Sect. Proc. 8:69–70. 1954, pub. 1955.
2. BUTCHER, J. E., BRANSON, F. A., BOOTH, W. E. and WARDEN, R. L. Loco-the taxonomy of the plants, a review of literature, and a report of current Montana research. Mont. Agr. Expt. Sta. Mimeo. C. 72, 22 p. Ref. Mar. 1953.
3. DUNHAM, R. S. Annual, winter-annual, and biennial weeds. No. Cent. Weed Control Conf. Res. Rpt. 11:35–48. 1954.
4. MEADLY, G. R. W. Weeds of Western Australia: Mexican poppy (*Argemone mexicana* L.) West. Austral. Dept. Agr. J. (ser.3) 3:401–403. July/Aug. 1954.
5. ————. Dangerous weed was once an ornament. Farmers' Wk. (Perth) 8(418):15. Feb. 3, 1955.

Classification and Identification

1. BASSETT, I. J. Check-list of weeds collected in the southern portions of Sudbury and Algoma Districts in Ontario, Canada, 1954. Canada Natl. Weed Comt. East. Sect. Proc. 8:103–112. 1954, published 1955.
2. CAPLENOR, D. An annotated list of the vascular plants of the gorges of the Fall Creek Falls State Park. Tenn. Acad. Sci. J. 30:93–108. Apr. 1955.
3. EDWARDS, J. C., and SRIVASTAVA, R. N. Weeds of the Allahabad Agricultural Institute campus. Allahabad Farmer 28:86–100. May 1954.
4. IMPORTANT AUSTRALIAN WEEDS. Rur. Res. C.S.I.R.O. 11:20–22. Mar. 1955.
5. KASAHARA, Y. Studies on the species of weeds in Japan and their geographical distribution. V. (In Japanese) Nogaku Kenkyu 42:97–113. Ref. Dec. 1954.
6. MEADLY, G. R. W. Weeds of Western Australia; caltrop (*Tribulus terrestris* L.). West. Austral. Dept. Agr. J. (ser.3) 3:673–675. Nov./Dec. 1954.
7. MELDERIS, A., and BANGERTER, E. B., eds. Handbook of British flowering plants. London, Ward, Lock & Co., 1955. 359 p.
8. MONTGOMERY, F. H. Common weeds of Ontario. Ontario Dept. Agr. B. 505, 104 p. Feb. 1955.
9. MUENSCHER, W. C. L. Weeds. Ed. 2. New York, Macmillan. 1955. 560 p.
10. MUENSCHER, W. C., and Schumacher, G. J. List of names, common and scientific, of the weeds of New York. N. Y. State Col. Agr. Ext. Cornell Ext. B. 927, 15 p. Jan. 1955.
11. ORCHARD, H. E. Weeds of South Australia: soldier thistle (*Cirsium acarna Moench*). So. Austral. Dept. Agr. J. 58:286–287. Feb. 1955.
12. PHILLIPS, C. E. Know your weeds—the key to a successful program. Noeast. Weed Control Conf. Proc. 8:53–54. 1954.

13. PUTNAM, N. F. New weeds of British Columbia. Brit. Columbia Agron. Assoc. Conf. Rpt. 1955:26–27.
14. SALISBURY, SIR. E. J. Weed dispersal and persistence. Sports Turf Res. Inst. J. 8:378–386. 1954.
15. WOLFE, H. H. Weeds of Washington. Wash. State Col. Ext. Mimeo. 1593, 101 p. 1954?

Ecological Investigations & Surveys

1. AREND, J. L. Chemical herbicides as tools in forest management. Soc. Amer. Foresters. Proc. 1954: 194–198.
2. BRAMBLE, W. C., and BYRNES, W. R. Progress report on the effect of certain common brush control techniques and materials on game food and cover on a power line right-of-way. Noeast. Weed Control Conf. Proc. 8:465–470. 1954.
3. ———, and ———. Progress report on the effect of certain brush control techniques and materials on game food and cover on a power line right-of-way. II. Noeast. Weed Control Conf. Proc. 9:417–427. 1955.
4. BURROWS, V. D., and OLSON, P. J. Reaction of small grains to various densities of wild mustard and the results obtained after their removal with 2,4–D or by hand. I. Experiments with wheat. Canad. J. Agr. Sci. 35:68–75. Jan/Feb. 1955.
5. CARMER, S. G. Invasion by rocket (*Barbarea vulgaris*). What's New Crops & Soils 7(3):13,24. Dec. 1954.
6. EDMOND, D. B. The effect on an establishing pasture of spraying with sodium 2–methyl–4–chlorophenoxycetate. New Zeal. J. Sci. & Technol. A., Agr. Res. Sect. 36:548–556. April 1955.
7. EGLER, F. E. The Bald Eagle State Forest right-of-way, Pennsylvania: plants take over future brush control. Noeast. Weed Control Conf. Proc. 8:459–463. 1954.
8. ———. The grassy right-of-way: invitation to costly respraying. Noeast. Weed Control Conf. Proc. 8:471–475. 1954.
9. ELIASON, E. J. The use of oil spray to control weeds in coniferous seedbeds. Noeast. Weed Control Conf. Proc. 8:411–414. 1954.
10. FERRELL, E. K. Chemical weed control in shelterbelts. No. Cent. Weed Control Conf. Proc. 11:117–119. 1954.
11. FOSTER, C. H. The use of silvicides to establish white pine by natural reproduction. Noeast. Weed Control Conf. Proc. 8:415–419. 1954.
12. GOOR, C. P. VAN. Chemical weed control in forestry. (In Dutch) Nederland. Heidemaatsch. Tijdschr. 66:98–106. Apr. 1955.
13. GRANSTROM, B. Weeds and rain are good allies. (In Swedish) Mjolkpropagandan 31:214–215. 1954.
14. HAMILTON, K. G., and BUCHHOLTZ, K. P. Some effects of quackgrass on the development of weedy species. Agron. Abs. 46:95. 1954.
15. JACKSON, W. C. Weed control with flame. Natl. Reclam. Assoc. Proc. 23:76–78. 1954.
16. LEONARD, G. M. Fire vs. brush. West. Forestry & Conserv. Assoc. Proc. 45:14–16. 1954.
17. LOEFFLER, G. Environment and rate of application studies on bean preemergence weed control with CIPC. Noeast. Weed Control Conf. Proc. 9:177–181. 1955.
18. MUENSCHER, W. C., and SCHUMACHER, G. J. List of names, common and scientific, of the weeds of New York. N. Y. State Col. Agr. Ext. Cornell Ext. B. 927, 15 p. Jan. 1955.
19. MURPHY, A. H. Vegetational changes during biological control of Klamath weed (*Hypericum perforatum*). J. Range Mangt. 8:76–79. Mar. 1955.
20. NEW HAMPSHIRE, STATE DEPT. OF HEALTH. BUR. OF OCCUPATIONAL HEALTH. Ragweed free areas in New Hampshire. Concord, 1955.
21. NIERING, W. A. Herbicide research at the Connecticut Arboretum. Noeast. Weed Control Conf. Proc. 9:459–462. 1955.
22. PALFREY, G. D. Ragweed seed survey, 1954. Canada. Natl. Weed Comt. East. Sect. Proc. 8:120–130. 1954. Pub. 1955.

23. PANDE, H. K. Studies on crop-weed competition in wheat field. (Abs.) Indian Sci. Cong. Proc. 40(3):145. 1953., pub. 1954.
24. RUSKIN, J. H. Public health significance of ragweed control demonstrated in Detroit. Noeast. Weed Control Conf. Proc. 8:489–501. Ref. 1954.
25. SACHS, M. Public health significance of ragweed control. Noeast. Weed Control Conf. Proc. 8:483–488. 1954.
26. SHIPMAN, R. D. Release of loblolly pine (*Pinus taeda*) by various weeding methods. U.S. Forest Serv. Soeast. Forest Expt. Sta. Res. Note 65, 2p. Oct. 1954.
27. SMITH, R. H. Some plants to leave alone. N. Y. State Conserv. 9(6):16–17. June/July 1955.
28. SONNEMA, M., and MOOI, H. Eindverslag van het onderzoek naar de verandering der akkeronkruidvegetatie in de loop van het seizoen (project 218) (Final report of research on the changes in field weed vegetation in the course of the season (Project 218)). Wageningen. Cent. Inst. v. Landbk. Onderz. Gestencilde Meded. 12, 16 p. 1954.
29. STEWART, W. G. Don't ruin farm potential by planting weeds. Colo. A & M News 8(6):4. Dec. 1953.
30. WALDRIP, W. J. Brush control, grazing management and revegetation of areas infested with blueberry cedar (*Juniperus ashei*). Tex. Agr. Expt. Sta. Prog. Rpt. 1721, 5 p. Sept. 30, 1954.
31. WILHELM, S., and BENSON, L. C. Weeds as important interim hosts of broomrape (*Orobanche ramosa*). Plant Dis. Rptr. 39:273. Mar. 15, 1955.

Physiological Investigations

1. ABERG, B. Studies on plant growth regulators. X. On the reproducibility of root growth results. Sweden. Lantbrhogsk. Ann. 21:197–211. Ref. 1954.
2. ALDRICH, R. J. Tolerance of red clover and alfalfa to fall applications of 2,4–D, MCP, 3,4–D, and 4–chloro. Noeast. Weed Control Conf. Proc. 9:289–291. 1955.
3. BACHTHALER, G. Die wirkung eines 2,4 D-haltigen unkrautbekampfungsmittels auf zuckerruben. Pflanzenschutz 6:92–93. July 1954.
4. BARLOW, H. W. B., HANCOCK, C. R., and LACEY, H. J. Some observations on growth inhibitors extracted from woody shoots. East Malling Res. Sta. Annu. Rpt. 1954:115–121. 1955.
5. BATJER, L. P. Precautions in the use of 2,4,5–TP as a stop-drop spray in central Washington. Wash. State Hort. Assoc. Proc. 50:79–80. 1954.
6. ————, SIEGELMAN, H. W., ROGERS, B. L., and GERHARDT, F. Results of four years' tests of the effect of 2,4,5–trichlorophenoxypropionic acid on maturity and fruit drop of apples in the Northwest. Amer. Soc. Hort. Sci. Proc. 64:215–221. Dec. 1954.
7. BHARDWAJ, S. N., and RAO, I. M. Studies on the effect of 2,4–D, NAA and IAA on growth and maturity of wheat. Indian Bot. Soc. J. 34:21–28. Ref. 1955.
8. BLACKMAN, G. E., and ROBERTSON-CUNINGHAME, R. C. Interrelationships between light intensity and the physiological effects of 2,4–dichlorophenoxyacetic acid on the growth of Helianthus annuus. J. Expt. Bot. 6:177–211. Ref. June 1955.
9. ————, and ————. Interrelationships between light intensity, temperature, and the physiological effects of 2,4–dichlorophenoxyacetic acid on the growth of Lemna minor. J. Expt. Bot. 6:156–176. June 1955.
10. BLOMMAERT, K. L. J. Growth-and inhibiting-substances in relation to the rest period of the totato tuber. Nature (London) 174:970–972. Ref. Nov. 20, 1954.
11. BOLL, W. G. Inhibition of growth of excised tomato roots by desoxypyridoxin and its reversal by pyridoxin. Science 120:991–993. Dec. 10, 1954.
12. BORGER, P. The calcium factor in the differential response of brush species to the esters of D & T. So. Weed Conf. Proc. 8:240–243. 1955.

13. BRADLEY, M. V., and CRANE, J. C. The effect of 2,4,5–trichlorophenoxyacetic acid on cell and nuclear size and endopoyploidy in parenchyma of apricot fruits. Amer. J. Bot. 42:273–281. Ref. Mar. 1955.
14. BRAY, D. F. Further investigations on the effect of spray materials on the finish of apples. Del. Bd. Agr. B. 44(5):63–66. 1954.
15. BURSTROM, H. Activity of plant growth regulators. Ann. Appl. Biol. 42: 158–161. Feb. 1955.
16. CARLONE, C. The use of growth substances as a means of modifying time of fruit harvest. (In Italian) Colt. e Gior. Vinic. Ital. 100:370–372. July 1954.
17. CARVELL, K. L. Translocation of ammate. Forest Sci. 1:41–43. Mar. 1955.
18. CHAKRAVARTI, S. C., and PILLAI, V.N.K. The effects of certain synthetic growth regulators on the vernalization of *Brassica campestris* L. Indian Sci. Cong. Assoc. Proc. 42(3,abs.):253. 1955.
19. CHOUDHRI, R. S., and BHATNAGAR, V. B. Effect of certain growth regulating substances on the germination of sugarcane setts. Banaras Hindu U. J. Sci. Res. 4:149–156. 1953/54.
20. COLLIN, R. La defense des cultures; le desherbage. Union Agr. 27:27–31. Mar. 15, 1955.
21. CRANE, J. C. Frost resistance, and reduction in drop of injured apricot fruits effected by 2,4,5–trichlorophenoxyacetic acid. Amer. Soc. Hort. Sci. Proc. 64:225–231. Ref. Dec. 1954.
22. DANIEL, W. H. Arsenic inhibition in *Poa annua* control. Agron. Abs. 46:92. 1954.
23. DAVIS, J. C., and KLINGMAN, G. C. The herbicidal influence of 2,4–D, potassium chloride and wetting agents in ammonium nitrate solution and the effect of wetting agents on surface tension. Agron. Abs. 46:94. 1954.
24. DAVY, J. Seasonal rhythms and plant growth. Star and Furrow 3:12–15. Autumn 1954.
25. DERSCHEID, L. A. You have to put weeds on a starvation diet. Dakota Farmer 75(7):6, 16. Apr. 2, 1955.
26. DORACHNER, K. P., and BUCHHOLTZ, K. P. Wettability of leaves by herbicidal sprays as a factor influencing stands of alfalfa seedlings. Agron. Abs. 46:84. 1954.
27. DUINTJER, E., and JONSSON, A. Synthetic plant hormones. VI. Acta Chem. Scand. 8:1493–1494. 1954.
28. DUNKEL, E. E., KAZLOVA, N. A., and KIETSE, V. T. Effect of maleic hydrazide on the development of plants. (In Russian) Latv. PSR Zinatnu Akad. Vest. 9:89–96. Ref. 1954.
29. DUPLESSY-GRAILLOT, G. Action conjuguee de la vitamine K_5 et de l'acide 2–4–dichlorophenoxyacetique sur la culture de fragments de topinambour et de souche de tissus de carotte. Ann. Biol. 59:45–52. Ref. Jan./Apr. 1955.
30. EASTWOOD, T., and COBB, J. S. The effect of herbicides upon potatoes used for chipping. Noeast. Weed Control Conf. Proc. 8:167–175. 1954.
31. ————, and ————. The effect of herbicides upon potatoes used for chipping. Noeast. Weed Control Conf. Proc. 9:245–254. 1955.
32. ELLENWOOD, C. W., and HOWLETT, F. S. Study further progress of chemicals for thinning apples. Ohio Farm & Home Res. 40:45–46. May/June 1955.
33. ERICKSON, L. C., and RICHARDS, S. J. Valencia orange size and 2,4–D; adequate soil moisture important for increasing fruit sizes with 2,4–D sprays applied when fruits are 4–12 weeks old. Calif. Agr. 9(5):9–10, 14. May 1955.
34. FURRER, J. D., and CHESNIN, L. Influence of fertilization and 2,4–dichlorophenoxyacetic acid applications on the total nitrogen content and the nitrate fraction of several plant species. Agron. Abs. 46:95. 1954.
35. HALLER, M. H. Effect of 2,4,5–trichlorophenoxypropionic acid on maturity and storage quality of apples. Amer. Soc. Hort. Sci. Proc. 64:222–224. Ref. Dec. 1954.

36. HALSE, N. J. The effectiveness of 2,4–D in preventing pre-harvest drop of navel oranges. West. Austral. Dept. Agr. J. (ser. 3) 3:670–672. Nov./Dec. 1954.
37. HARRIS, V. C. Influence of the growth rate of cotton plants upon their response to directional sprays of CIPC in four solvents. So. Weed Conf. Proc. 8:31–36. 1955.
38. HARTZFELD, H. A. Some correlations of chemical constitution and plant hormone action. (Abs.) Iowa State Col. J. Sci. 29:420–421. Feb. 15, 1955.
39. HAUN, J. R., and PETERSON, J. H. Translocation of 3–(p-chlorophenyl)–1, l-dimethylurea in plants. Weeds 3:177–187. Apr. 1954.
40. ILNICKI, R. D., and WILLARD, C. J. Critical periods in treating corn with 2,4–D. Agron. Abs. 46–95. 1954.
41. IMAMURA, H., and MAEHARA, T. Control of tobacco sucker with maleic hydrazide. I. (In Japanese Kyushu Agr. Res. 15:33–34. Apr. 1955.
42. JORDAN, L., and DUNHAM, R. S. Influence of rates and time of application and tillage practices on residual effects of CMU. No. Cent. Weed Control Conf. Proc. 11:14–15. 1954.
43. KAUFMAN, P. B. Histological responses of the rice plant (*Oryza sativa*) to 2,4–D. Amer. J. Bot. 42:649–659. Ref. July 1955.
44. KEFFORD, N. P. The growth substances separated from plant extracts by chromatography. II. J. Expt. Bot. 6:245–255. June 1955.
45. KINPYO, T., and KAMIYA, S. Studies on maleic hydrazide and its related compounds (injurious action of maleic hydrazide on sprouting of rice seed). (In Japanese) Shizuoka U. Facul. Agr. Rpt. 4:115–128. Ref. 1954.
46. KOFLER, L. Action du 2, 4–dichlorophenoxyacetate de sodium sur les premiers stades du developpement de Sphagnum papillosum Lindb. Acad. des Sci. Compt. Rend. 239:1417–1420. Nov. 22, 1954.
47. KREWSON, C. F., NEUFELD, C. H. H., DRAKE, T. F., FONTAINE, T. D., MITCHELL, J. W., and PRESTON, W. H. Synthetic plant-growth modifiers. IV. 2–methyl–4–chlorophenoxyacetyl derivatives of amino acids. Weeds 3:28–37. Ref. Jan. 1954.
48. KRISHNAMURTHI, S., and SUBRAMANIAN, D. Some investigations on the types of flowers in brinjal (*Solanum melongena*), based on style length, and their fruit-set under natural conditions and in response to 2,4–dichlorophenoxy acetic acid as a plant growth-regulator. Indian J. Hort. 11: 63–66. June 1954.
49. ————, and ————. Some studies on the effect of 2,4–dichlorophenoxy acetic acid in hastening the maturity of brinjals and increasing fruit set. So. Indian Hort. 1:125–128. Feb. 1954.
50. LEVI, E. The inhibition of the growth of perennial grasses by maleic hydrazide. Austral. J. Agr. Res. 6:378–387. Ref. May 1955.
51. LONGCHAMP, R. Principes d'utilisation des herbicides. B. d'Inform. des Riziculт. de France 38:2–6. May/June 1955.
52. LOOMIS, W. E. Basic studies. No. Cent. Weed Control Conf. Res. Rpt. 11:158–176. 1954.
53. ————. Resistance of plants to herbicides. In Sevag, M. G., ed. Origins of resistance to toxic agents, p. 99–121. Ref. New York, Acad. Press, 1955.
54. LOTT, R. V., and RICE, R. R. Effect of pre-harvest sprays of 2,4,5–trichlorophenoxypropionic acid upon the maturation of fruits of important summer-maturing apple varieties. Ill. Agr. Expt. Sta. B. 588, 31 p. Ref. June 1955.
55. ————, and ————. Effect of pre-harvest sprays of 2,4,5–trichlorophenoxypropionic acid upon the maturation of Jonathan, Starking, and Golden Delicious apples. Ill. Agr. Expt. Sta. B. 589, 29 p. Ref. June 1955.
56. LUCKWILL, L. C., and WOODCOCK, D. Plant growth regulators. I. The influence of side-chain length on the activity of w-(2–naphthyloxy)-n-alkylcarboxylic acids for the induction of parthenocarpy in tomatoes. J. Hort. Sci. 30:109–115. Apr. 1955.

57. MACLEAN, S. M., MATTHEWS, L. J., and FITZGERALD, J. N. Tolerance of clovers to weedkillers. New Jeal. J. Agr. 90:450–451, 453, 455, 457. May 16, 1955.
58. MARLE, G. S. Improvement of color of fruit through spraying with growth substances. (In Dutch) Fruitteelt 44:725. Aug. 28, 1954.
59. MASSY, D. J. R. Maleic hydrazide, plant growth inhibitor. Mfg. Chem. 26:197–200. May 1955.
60. MATTUS, G. E., and MOORE, R. C. Preharvest growth regulator sprays on apples. I. Drop and maturity 1952 and 1953. Amer. Soc. Hort. Sci. Proc. 64:199–208. Ref. Dec. 1954.
61. MEGGITT, W. F., BORTHWICK, H. A., ALDRICH, R. J., and SHAW, W. C. Factors affecting the herbicidal action of dinitro-ortho-secondary butyl phenol. (Abs.) Noeast. Weed Control Conf. Proc. 8:21–22. 1954.
62. MICHEL, B. E. Growth responses of cabbage and radish hypocotyl sections to indoleacetic acid and indoleacetonitrile. (Abs.) Plant Physiol. 30(sup.):xi. 1955.
63. NARITA, T., YAMACINA, K., and DATE, Y. On the injection of chemicals into living tree. (In Japanese) Jap. Forestry Soc. J. 36:359–361. Dec. 25, 1954.
64. NILES, J. J. The use of triphenyl tetrazolium bromide in viability tests of rice seed. Trop. Agr. ((Peradeniya) 110:13–20. Jan/Mar. 1954.
65. PARKIN, A. The weed unlocks its own doom. Farmers Wk. (London) 42(17):89–90. Apr. 29, 1955.
66. PETERS, R. A. Some factors involved in the chemical control of quackgrass. Noeast. Weed Control Conf. Proc. 8:257–264. 1954.
67. PHOUPHAS, C. Action de l'hydrazide maleique sur la croissance et la teneur en substances glucidiques d'une souche de tissus de carotte cultives in vitro. Soc. de Chim. Biol. B. 37:331–334. 1955.
68. POPOV, M., and ILIEV, P. On some new practical methods of stimulation. (In Bulgarian) Bulgar. Akad. na Nauk. Biol. Inst. Izv. 5:303–308. 1954.
69. RAO, S. N., and WITTWER, S. H. Further investigations on the use of maleic hydrazide as a sprout inhibitor for potatoes. Amer. Potato J. 32:51–59. Feb. 1955.
70. REAVILL, M. J. Effect of certain chloronitrobenzenes on germination, growth and sporulation of some fungi. Ann. Appl. Biol. 41:448–460. Ref. Sept. 1954.
71. ROGERS, B. L., and BATJER, L. P. Effects of 2,4,5–T on size, maturity, and drop of apricots. Wash. State Hort. Assoc. Proc. 50:81–82. 1954.
72. ROSSI, A. Cytogenetic action of maleic hydrazide on the root tips of *Allium cepa* L. (In Italian) Caryologia 7:205–218. Ref. 1955.
73. RUDENBERG, L., FOLEY, G. E., and WINTER, W. D. Chemical and biological studies on 1, 2–dehydro-s-triazines. XI. Inhibition of root growth and its reversal by citrovorum factor. Science 121:899–900. Ref. June 24, 1955.
74. SANTELMANN, P. W., and WILLARD, C. J. The absorption and translocation of Dalapon. Noeast. Weed Control Conf. Proc. 9:21–29. 1955.
75. SHKVARNIKOV, P. K., and SOLOMKO, E. A. Utilization of chemical growth stimulators for breaking up dormancy in fresh-harvested potato tubers. (In Russian) Akad. Nauk SSSR. Izv. Ser. Biol. 5:55–65. Ref. Sept./Oct. 1954.
76. SIJPESTEIJN, A. K. The mode of action of sodium dimethyldithiocarbamate and tetramethylthiuram disulphide on *Aspergillus niger*. Cong. Internatl. de Phytopharm. (Compt. Rend.) 3(2):584–590. Ref. 1952, pub. 1954.
77. SKOGLEY, C. R. The influence of wetting agents on the phytotoxicity of several herbicides. Noeast. Weed Control Conf. Proc. 8:293–299. 1954.
78. SLIFE, F. W. The effect of post-emergence 2,4–D sprays on growth and development of soybeans. No. Cent. Weed Control Conf. Proc. 11:42. 1954.
79. SLITS, H. J. A. Fruit thinning raises the quality of your apples. (In Dutch) Boer en Tuinder 9 (442,i.e.423):6. Apr. 9, 1955.
80. SMITH, D. E. Evaluation of chemical rooting agents in rooting *Saintpaulia*. African Violet Mag. 8(4):48–54. June 1955.

81. SMITH, D. M., HUTNIK, R. J., and PAULSEN, H. A. Relationship between concentration of basal sprays and mortality of red maple (*Acer rubrum*) sprout clumps. Noeast. Weed Control Conf. Proc. 8:435–439. 1954.
82. SMITH, F. D. The revolution in weedkilling. Discovery 16:334–338. Aug. 1955.
83. SMITH, R. J. A study of the comparative effects of dinitro-o-sec butyl phenol and isopropyl-n-(3-chlorophenyl) carbamate on soybeans. Agron. Abs. 46:97. 1954.
84. STONE, J. D., and RAKE, D. W. Effect of borate additives on herbicides. Agr. Chem. 10(5):36–38, 123, 125. May 1955.
85. ———, and ———. Effect of borate additives on herbicidal qualities of 2,4-D (Abs.) No. Cent. Weed Control Conf. Proc. 11:7–8. 1954.
86. STRIETMAN, H. Fruit set of apples. (In Dutch) Groenten en Fruit 10:293. Sept. 30, 1954.
87. TAFURO, A. J., BEATTY, R. H., and GUEST, R. T. Progress report of crop tolerance period following various rates of Amizol (3-amino-1,2,4-triazole) on Ewingsville soil. Noeast. Weed Control Conf. Proc. 9:31–39. 1955.
88. TEMPLEMAN, W. G. The uses of plant growth substances. Ann. Appl. Biol. 42:162–173. Ref. Feb. 1955.
89. TEUBNER, F. G., and WITTWER, S. H. Effect of N-m-tolylphthalamic acid on tomato flower formation. Science 122:74–75. July 8, 1955.
90. THOMPSON, A. H. Considerations in the use of chemical thinning sprays on apple trees. Md. State Hort. Soc. Proc. 56:1–8. 1954.
91. ———, and STAHLY, E. A. Recent experiments with chemical thinning sprays on apples and peaches. Del. Bd. Agr. B. 44(5):53–59. 1954.
92. TONZIG, S., and TREZZI, F. Research on the physiology of ascorgic acid. VIII. Action of indole-3-acetic acid and ascorbic acid on the absorption and loss of water by plant tissues. (In Italian) Accad. Naz. dei Lincei. Cl. di Sci. Fis. Mat. e Nat. Atti. Rend. (ser. 8) 16:434–443. Apr. 1954.
93. TREVETT, M. F. The effect of spray volume on reduction of resprouting of red maple (*Acer rubrum*) following stub treatment with 2,4,5-T. Noeast. Weed Control Conf. Proc. 9:471–477. 1955.
94. TSYGANOV, M. S. Control of rhizomic and sucker-like weeds. (In Russian) Zemledelie 7:66–68. Dec. 1953.
95. UNRAU, J. Cytogenetic effects of 2,4-D on cereals. Canad. Seed Growers' Assoc. Annu. Rpt. 1953/54.
96. VALLEJO, E. S. El uso del herbicida "2,4-D" como acelerador de la fructificacion en la pina. Peru. Dir. Gen. de Agr. B. 9/10:23–26. Third/Fourth Q. 1953.
97. VAN OVERBEEK, J., and BLONDEAU, R. Mode of action of phytotoxic oils. Weeds 3:55–65. Ref. Jan. 1954.
98. VEATCH, C. Effect of some chemicals on weed growth and corn production. Noeast. Weed Control Conf. Proc. 8:273–281. 1954.
99. WANG, T. T. Effect of naphthaleneacetic acid on propagation of cypress cuttings. Natl. Taiwan U. Col. Agr. Mem. 3(3):27–42. May 1954.
100. WATSON, A. J. The response of cotton to low rates of 2,4-D, 2,4,5-T, MCP and Silvex. So. Weed Conf. Proc. 8:82–86. 1955.
101. WATSON, A. J., and NATION, H. A. The response of cotton to low rates of 2,4-D, 2,4,5-T, MCP and silvex. (Abs.) Assoc. South. Agr. Workers. Proc. 52:37. 1955.
102. WATSON, R. D. Galls similar to crown gall and nematode injury produced by 2,4-D. Plant Dis. Rptr. 39:381–394. May 15, 1955.
103. WEBBER, E. R. Maleic hydrazide as a growth inhibitor. World Crops 7:179–183. Ref. May 1955.
104. ———. Maleic hydrazide as a plant growth inhibitor. Chem. Prod. May 1955:179–180.
105. WEINTRAUB, R. L., YEATMAN, J. N., BROWN, J. W., THRONE, J. A., SKOSS, J. D., and CONOVER, J. R. Studies on entry of 2,4-D into leaves. Noeast. Weed Control Conf. Proc. 8:5–10. 1954.
106. WILLIAMS, J. H. Differential varietal response of oat varieties to 2,4-dichlorophenoxyacetic acid. Agron. J. 46:565–569. Ref. Dec. 1954.

107. WORLEY, D. P., BRAMBLE, W. C., and BYRNES, W. R. Effect of seasonal basal sprays on root suckering of aspen. Noeast. Weed Control Conf. Proc. 8:447–452. 1954.
108. WORT, D. J. The physiology of 2,4–D action. Brit. Columbia Agron. Assoc. Conf. Rpt. 1955:29–32.

Weed Seed Investigations

1. DEAN, E. Good seed, a prime requisite to weed control and successful farming. So. Weed Conf. Proc. 8:409–410. 1955.
2. SHARON, J. E. They'd planted weeds. Farmer (St. Paul) Gen. Ed. 73(6):20–21, 83. Mar. 19, 1955.
3. SMITH, W. D. The use of the Carter dockage tester to remove weed seeds and other foreign material from rough rice. Rice J. 58(9):26–27. Aug. 1955.
4. STEVENS, O. A. Weed seed facts. N. Dak. Agr. Col. Ext. C. A–218, 4 p. Nov. 1954.

III. WEED CONTROL

Cultural

1. BURCHAM, L. T., and SAMPSON, A. W. Costs of controlled burning and wildfire suppression affected by acreage burned. Calif. Cattleman, Nov. 1954:8–9.
2. FLETCHALL, O. H., KLINGMAN, D. L., and LARSON, R. E. The effect of some chemical weed control treatments on the cultivation requirements of corn. No. Cent. Weed Control Conf. Proc. 11:43–44. 1954.

Weeds In Field Crops

1. ALBERT, W. B., and BALK, W. A. Effects of heavy applications of preemergence herbicides to cotton in relation to seasonal conditions. So. Weed Conf. Proc. 8:37–41. 1955.
2. ALDRICH, R. J. Continued studies of chickweed control in alfalfa. Noeast. Weed Control Conf. Proc. 8:327–328. 1954.
3. ANDERSON, R. N., and HELGESON, E. A. Can fall preplanting treatments control wild oats (*Avena fatua*) in sugar beets? N. Dak. Agr. Expt. Sta. Bimo. B. 17:128–130. Mar./Apr. 1955.
4. ANTOGNINI, J., and DAY, H. M. Geigy 444, a new pre-emergence and post-emergence herbicide for cotton. So. Weed Conf. Proc. 8:92–98. 1955.
5. ARAI, M., KAWASHIMA, R., and KUMAZAKI, Y. Studies on weed control in rice culture by 2,4–dichlorophenoxyacetic acid. II-IV. (In Japanese) Kanto-Tosan Agr. Expt. Sta. J. 6:38–80. Nov. 1954.
6. ARLE, H. F., and EVERSON, E. H. Chemical control of annual morning glory and annual grasses in cotton. Ariz. Agr. Expt. Sta. B. 263, 8 p. May 1955.
7. BACHTHALER, G. Der einfluss einer uberdosis 2,4–D und 2,4,5 T–unkrautbekampfungsmittel auf verschiedene winterweizensorten. Z. F. Pflanzenbau u. Pflanzenschutz 6:40–48. 1955.
8. BARABE, R. Destruction chimique des manuvaises herbes dans les champs de cereales. Ferme 16(8):20, 95–97. Apr. 1955.
9. BEHRENS, R. Cotton responses to some herbicides used in brush and weed control. Tex. Agr. Aviation Conf. Papers 4:E1–E4. 1955.
10. BEREZOVSKII, M. IA. Chemical weeding in grain plantings. (In Russian) In V pomoshch' agronomu, v.1, p. 318–322. Moskva, Gosudarstvennoe Izdatel'stvo Sel'skokhoziaistvennoi Literatury, 1954.
11. BERGGREN, G. H., RALEIGH, S. M., COBB, J. S., FREAR, D. E. H., HORNE, B. S., PATTERSON, R. E., BRAMBLE, W. C., and PEPPER, J. O. Chemical weed control in farm crops, pastures, and brush. Pa. State U. Ext. C. 440, 21 p.
12. BESEMER, A. F. H., ORMEL, H. A., RIEPMA, P., and VAN DER ZWEEP, W. Verslag van de tweede britse onkruidbestrijdingsconferentie (1–3 November 1954, Harrogate) (Report of the second British Weed Control Conference (Nov. 1–3, 1954 (Harrogate)). Wageningen. Cent. Inst. v. Landbk. Onderz. Gestencilde Meded. 3,25 p. 1955.
13. BREAKEY, W. J. Spring sown grains. No. Cent. Weed Control Conf. Res. Rpt. 11:49–58. 1954.

14. BREESE, T. C. The early spray catches the weed. Farmers Wk. (London) 42(16):91,93. Apr. 22, 1955.
15. BROWN, R. H. Weeds in cereal crops. Wesfarmers News 3(21):9. May 26, 1955.
16. BULA, R. J. The control of weeds in Alaska field crops with dinitro sprays. No. Cent. Weed Control Conf. Proc. 11:52–53. 1954.
17. BURT, E. O., and WITHERSPOON, A. G. Chemical weed control in soybeans. So. Weed Conf. Proc. 8:171–178. 1955.
18. ———. Pre-emergence weed control in peanuts. So. Weed Conf. Proc. 8:127–129. 1955.
19. CHAPPELL, W. E. Chemical vs. cultural control of weeds in soybeans. Noeast. Weed Control. Conf. Proc. 8:301–306. 1954.
20. ———. Weed control in Virginia Jumbo Runner peanuts. So. Weed Conf. Proc. 8:136–142. 1955.
21. ———, and CAMPER, H. M. Weed control in soybeans. So. Weed Conf. Proc. 8:177–181. 1955.
22. ———, and LAPRADE, J. L. Weed control-tobacco seed beds. So. Weed Conf. Proc. 8:213–216. 1955.
23. COITEUX, F. L'enraiement des mauvaises herbes dans la cultures des betteraves a sucre. Assoc. Canad.-Franc. pour l'Avanc. des Sci. Ann. 20:69–72. 1952/53., pub. 1954.
24. CORMANY, C. E. Pre-emergence applications of a combination of TCA and endothal show promise for control of grassy and broadleaf weeds in sugar beets. (Abs.) Amer. Soc. Sugar Beet Technol. Proc. 8(1):135. 1954.
25. COSTA, L., and RUI, D. Anomalies of herbicides on sugar beets (*Beta vulgaris* L.) (In Italian) Inform. Agr. (Verona) 11:413. June 9, 1955.
26. COSTE, A. D. DELLE. Control de malezas en el cultivo de algodon. Chacra 25(291):74–75. Feb. 1955.
27. CURTIS, L. E., BARAN, W., FERRANT, N. A., PAPAI, M. J., and FLAGG, C. V. Field trials of planting applications of herbicides to corn. Noeast. Weed Control Conf. Proc. 8:283–286. 1954.
28. DAVIDSON, J. H., and SLIFE, F. W. The control of grasses in established alfalfa with Dalapon. No. Cent. Weed Control Conf. Proc. 11:38–41. 1954.
29. DAVIS, A. M. The effect of some post emergence herbicides on rice. So. Weed Conf. Proc. 8:189–192. 1955.
30. DAVIS, D. E., and SEARCY, V. S. Comparative efficiency of CIPC, DNOSBP, and 1:1 mixtures of these chemicals as a pre-emergence treatment for cotton. So. Weed Conf. Proc. 8:99–103. 1955.
31. DAVIS, W. C. 1954 rice field weed control in Texas. Rice J. 58(3):14, 16, 18–20. Mar. 1955.
32. ———. 1954 rice field weed control in Texas. So. Weed Conf. Proc. 8:182–188. 1955.
33. DERSCHEID, L. D. Chemical weed control in crops. S. Dak. State Col. Agr. Ext. L. 155, 6 p. Mar. 1954.
34. DESAYMARD, P. Action de l'acide 2,4–dichlorophenoxyacetique et de l'acide naphtylacetique sur la betterave a sucre traitee en cours de vegetation. Cong. Internatl. de Phytopharm. (Compt. Rend.) 3(2):718–720. 1952, pub. 1954.
35. DETROUX, L. Renseignements techniques sur l'emploi des herbicides dans nos principales plantes cultivees. Rev. de l'Agr. 8:157–169. Ref. Feb. 1955.
36. DIRVEN, J. G. P., and POERINK, H. J. Weeds in rice and their control in Suriname. Trop. Agr. (St. Augustine) 32:115–123. Apr. 1955.
37. DOMANGUE, D. A. Practical aspects of extensive chemical weed control in Louisiana sugarcane. Amer. Soc. Sugar Cane Technol. Proc. 4:24–28. 1950–53, pub. Jan. 1955.
38. DUNHAM, R. S. 2,4–D or MCP for weed control in flax, oats, legumes. No. Cent. Weed Control Conf. Proc. 11:119–120. 1954.
39. ECKROTH, E. G. Results with IPC spraying in eastern Montana. (Abs.) Amer. Soc. Sugar Beet Technol. Proc. 8(1):135. 1954.
40. ELDER, W. C. Sorghum. No. Cent. Weed Control Conf. Res. Rpt. 11:60–61. 1954.

41. ————. Winter wheat. No. Cent. Weed Control Conf. Res. Rpt. 11:59. 1954.
42. ELLIOTT, F. C. Extension aspects of weed control in cotton in Texas in 1954. So. Weed Conf. Proc. 8:416–418. 1955.
43. FAZ, A. B. Saneamiento de potreros con herbicidas aplicados por avion. Asoc. de Tec. Azucareros de Cuba Mem. de la Conf. Anu. 27:73–82. 1953, pub. 1954.
44. FERTIG, S. N., and SCHREIBER, M. M. 1955 weed control in field crops. N. Y. State Col. Agr. Ext. Cornell Ext. B. 821, rev., 6 p.—folder. Jan. 1955.
45. FLAME CULTIVATING IN ARIZONA; some good results have been obtained at Arizona University's Marana Farm. Acco Press 35(5):8–10. May 1955.
46. FRIBOURG, H. A., and JOHNSON, I. J. Response of soybean strains to 2,4–D and 2,4,5–T. Agron. J. 47:171–174. Apr. 1955.
47. FRIEDERICH, J. C. Weed control in flax. (In Dutch) Friesch Landbbl. 52:408. May 6, 1955.
48. ————. Weed control in flax. (In Dutch) Nieuwe Veldbode 21:595–596. Apr. 28, 1955.
49. ————. Weed control in flax. (In Dutch) Zeeuwsch Landbbl. 43:284. Apr. 23, 1955.
50. GAJIC, D. Synopsis of weeds growing in clover and lucerne fields of Serbia. (In Serbo-Croatian) Zastita Bilja 25:60–72. Ref. 1954.
51. GT. BRIT. MINISTRY OF AGRICULTURE AND FISHERIES. Application of selective weed-killers to cereals. Gt. Brit. Min. Agr. & Fisheries. Adv. L. 315, rev., 8 p. Feb. 1955.
52. ————. Weed Control in cereals by selective weed-killers. Gt. Brit. Min. Agr. & Fisheries. Adv. L. 436, 7 p. Feb. 1955.
53. GRIGSBY, B. H. Sugar beets. No. Cent. Weed Control Conf. Res. Rpt. 11:95–98. 1954.
54. GUZMAN, V. L. Herbicidal controls of weeds in sugarcane on organic soils. So. Weed Conf. Proc. 8:203–206. 1955.
55. HARTEL, K. Dinitro-o-sec-butylphenol-wirkungsweise und anwendungsmoglichkeiten zur unkrautbekampfung. (Abs.) Angew. Chem. 67:311–312. June 7, 1955.
56. ————. Untersuchungen uber die dampfphase verschiedener, 2,4–D-und MCP-ester. (Abs.) Angew. Chem. 67:311. June 7, 1955.
57. HARVEY, W. A., and DAVIS, L. L. Weed control in California rice—1953. Rice J. 58(3):22, 24. Mar. 1955.
58. HELMS, C. C. Weed control in peanuts. So. Weed Conf. Proc. 8:130–135. 1955.
59. HENDERSON, J. H. M. Further variations in response of oat and pea sections to 2,4–D and other substances. (Abs.) Plant Physiol. 30(sup.):vi-vii. 1955.
60. ILNICKI, R. D. Critical periods in the application of 2,4–D to corn. Diss. Abs. 15:928–929. June 1955.
61. ————, and WILLARD, C. J. The use of dinitros on corn. (Abs.) No. Central Weed Control Conf. Proc. 11:43. 1954.
62. JONES, G. Chemical weed control in soybeans. Canada Natl. Weed Comt. East. Sect. Proc. 8:113–115. 1954, pub. 1955.
63. KASASIAN, L. Weed control on agricultural land. Yorkshire Agr. Soc. J. 106:11–17. 1955.
64. KLINGMAN, D. L. Forage legumes. No. Cent. Weed Control Conf. Res. Rpt. 11:81–91. 1954.
65. KLINGMAN, G. C. Pre-emergence weed control in corn using amides of chloroacetic acid derivatives of dithiocarbamic acid, substituted ureas, and 2,4–D. So. Weed Conf. Proc. 8:148–151. 1955.
66. ————, and DAVIS, J. C. Ammonium nitrate solution, 2,4–D and "Karmex M" for weed control in corn. Agron. Abs. 46:95–96. 1954.
67. KOVTANIUK, M. Spraying spring wheat plantings with 2,4–D preparation in a mixture with mineral fertilizers. (In Russian) Zemledelie 3:104–105. Jan. 1955.
68. KUHN, A. O., GARVEY, W. E., SCHUTTE, T. H. and WILCOX, M. The effect of selected herbicides applied at the time of band seeding alfalfa. Noeast. Weed Control Conf. Proc. 9:293–299. 1955.

69. LACROIX, L., and DETROUX, L. Essais de desherbage chimique des cultures de mais. Rev. de l'Agr. 8:170–184. Feb. 1955.
70. LANSAC, P. R. Le desherbage des cereales. Phytoma 7(66):7–15. Mar. 1955.
71. LEASURE, J. K. Chemical weed control experiments with cotton 1951–1954. Tenn. Agr. Expt. Sta. B. 240, 11 p. Mar. 1955.
72. LIPSHITZ, N. Control of *Cynodon dactylon* and Sorghum halepense in alfalfa areas. (In Hebrew) Hassadeh 35:765–766. July 1955.
73. LORINC, I., and ANDRISKA, V. Dinitroorthocresol—ein vielseitiges pflanzenschutzmittel. (In Hungarian) Magyar Kem. Lapja 10:81–83. Mar. 25, 1955.
74. LYERLY, P. J. Pre-emergence herbicides for the control of weeds in cotton in the El Paso Valley, 1954. So. Weed Conf. Proc. 8:61–64. 1955.
75. MARSHALL, E. R. Weed control in field corn following planting and emergence applications of herbicides. Noeast. Weed Control Conf. Proc. 9:257–264. 1955.
76. ———, and LOEFFLER, G. A comparison of different herbicides applied at planting, at emergence, and post-emergence on field corn. Noeast. Weed Control Conf. Proc. 8:264–272. 1954.
77. MCCALL, G. L. The use of CMU in the sugar industry. Amer. Soc. Sugar Cane Technol. Proc. 4:17–23. 1950–53, pub. Jan. 1955.
78. MILLER, J. H., and FOY, C. L. Weed control in cotton. I-II. Calif. Weed Conf. Proc. 7:73–82. 1955.
79. ———, and ———. The control of established Johnson grass (Sorghum halepense) in cotton by spot treatment. So. Weed Conf. Proc. 8:104–109. 1955.
80. MITCHELL, F. L. Weed control on the farm. Minn. Seed Grower 28(2):1, 3. Apr. 1955.
81. MOTTA, E. Chemical weed control of cereals and particularly wheat. (In Italian) Nuova Agr. Lucana 3:53–56. Apr. 1955.
82. NELSON, R. T. Grass control in sugar beet with the herbicides IPC, TCA and DCU. Amer. Soc. Sugar Beet Technol. Proc. 8(1):130–134. 1954.
83. NOLL, C. J., and ODLAND, M. L. Beet weed control experiments in 1954. Noeast. Weed Control Conf. Proc. 9:223–225. 1955.
84. NOONAN, J. C. Preliminary observations in the use of herbicides on crops. So. Weed Conf. Proc. 8:357–358. 1955.
85. ORSENIGO, J. R., and WALKER, R. K. Premergence herbicide experiments in Upland rice in Venezuela, South America, 1953–1954. So. Weed Conf. Proc. 8:193–200. 1955.
86. ORTH, H. Neue herbizide im gemusebau. Gesunde Pflanzen 7:129–131. June 1955.
87. OWENS, C. B. The effects of herbicides on weeds and corn when applied as pre-emergence and post-emergence sprays. So. Weed Conf. Proc. 8:152–158. 1955.
88. PANDE, H. K. Effect of sodium dichlorophenoxyacetae on crop and weeds in wheat field. Agra U. J. Res. Sci. 3:241–252. Ref. Jan. 1954.
89. PAYREBRUNE ST. SEVE, G. BARON DE. Moglichkeiten der chemischen unkrautbekampfung im gemusebau. Z. f. Acker- u. Pflanzenbau 99:334–360. Ref. May 1955.
90. PEABODY, D. V., and JOHNSON, C. M. Chemical weed control in new forage seedings. Agron. Abs. 47:78. 1955.
91. PETERS, R. A. Preliminary report on the effect of weed control chemicals on new forage seedlings. Noeast. Weed Control Conf. Proc. 8:331–339 1954.
92. ———. Herbicides for perennial grass control in alfalfa and Ladino clover stands. Agron. Abs. 47:78. 1955.
93. PHILLIPS, W. M. Chemical drying and pre-harvest weed control. No. Cent. Weed Control Conf. Res. Rpt. 11:137–139. 1954.
94. ———. The effects of 2,4–D and MCP on sorghum. No. Cent. Weed Control Conf. Proc. 11:59–62. 1954.
95. PIACCO, R. Weeds infesting Italian rice fields. (In Italian) Italia Agr. 92:88–95. Feb. 1955.

96. POIGNANT, P. Conditions pratiques sur le desherbage du riz avec les phytohormones herbicides. B. d'Inform. des Riziculf. de France 38:19–23. May/June 1955.
97. ———, and CHAFFARD, M. Quatre annees d'experimentation sur le desherbage chimique de la betterave sucriere par la technique de pre-emergence. Acad. d'Agr. de France. Compt. Rend. 2:74–81. Jan. 26/Feb. 2, 1955.
98. RALEIGH, S. M. New chemicals promise quack grass (*Agropyron repens*) control in corn. Sci. Farmer (Pa. Sta.) 2(4):9. Spring 1955.
99. ———, ANDERSON, P. M., and PATTERSON, R. E. Weed control in corn in Pennsylvania. Noeast. Weed Control Conf. Proc. 8:287. 1954.
100. ———, PATTERSON, R. E., and ANDERSON, P. M. Weed control in corn. Noeast. Weed Control Conf. Proc. 9:275–276. 1955.
101. REA, H. E. Controlling weeds in cotton fields. Cotton Gin & Oil Mill Press 56(4):40–41. Feb. 12, 1955.
102. ———. Control of early weeds in cotton. So. Weed Conf. Proc. 8:57–60. 1955.
103. ———. The control of weeds in corn and peanuts. So. Weed Conf. Proc. 8:143–147. 1955.
104. ———. Controlling weeds in cotton. Agron. Abs. 47:78–79. 1955.
105. ROBERTSON, C., ZENGER, W. G., and CAVALERO, J. Chemical weed control in corn and Blue Lake beans, a panel. Oreg. State Hort. Soc. Proc. 46:131–134. 1954.
106. RUSHMORE, F. A. Field observation in the use of pre-emergence weed control in corn. Oreg. State Hort. Soc. Proc. 46:135–136. 1954.
107. SAND, P. F. Control of weeds in spring seeded alfalfa. No. Cent. Weed Control Conf. Proc. 11:36–38. 1954.
108. SANTELMANN, P. W., and WILLARD, C. J. MCP, DNBP, 3,4–D and 2,4–D as herbicides on alfalfa sown in oats. No Cent. Weed Control Conf. Proc. 11:41–42. 1954.
109. SCHALLOCK, D. A. Weed control in crops, a benefit to agriculture and health. Noeast. Weed Control Conf. Proc. 9:479. 1955.
110. SCHMIDT, O. Vergleichende untersuchungen uber die herbizide wirkung der synthetischen wuchsstoffe 2,4–D und MCPA. Biol. Zentanst. f. Land- u. Forstwirt. Mitt. 77,119 p. Ref. Jan. 1954.
111. SCHREIBER, M. M., and FERTIG, S. N. Preliminary results of pre- and post-emergence screening experiments on legumes. Noeast. Weed Control Conf. Proc. 8:313–317. 1954.
112. ———. A comparison of MCP and 2,4–D for weed control in forage legumes. Noeast. Weed Control Conf. Proc. 9:325–334. Ref. 1955.
113. ———. Results of field trials with 3,4–D on alfalfa and medium red red clover. Noeast. Weed Control Conf. Proc. 9:335–339. 1955.
114. ———. The potential of post-harvest spraying of forage legumes. Agron. Abs. 47:79. 1955.
115. SCOTT, W. O. How to control weeds in corn. Hoard's Dairyman 100:455, 476–477. May 10, 1955.
116. SEARCY, V. S. Chemical weed control in cotton cuts hoe labor 80–100%. Highlights Agr. Res. (Ala. Sta.) 2:7. Spring 1955.
117. SHAW, W. C., WILLARD, C. J., and BERNARD, R. L. The effect of 2,4–dichlorophenoxyacetic acid (2,4–D) on wheat, oats, barley, and the legumes underseeded in these crops. Ohio Agr. Expt. Sta. Res. B. 761, 24 p. Ref. Apr. 1955.
118. SHEAR, G. M., and CHAPPELL, W. E. Can Dalapon be used safely on field corn. So. Weed Conf. Proc. 8:159–161. 1955.
119. SHEBESKI, L. H. Effect of mustard in wheat and flax. No. Cent. Weed Control Conf. Proc. 11:124–125. 1954.
120. SIAN, S. M. Weeds—rice plant's greatest pest. Coop. Farmer (Manila) 2(9):6, 38. Oct. 1954.
121. SLIFE, F. W. Soybeans and peas. No. Cent. Weed Control Conf. Res. Rpt. 11:72–80. 1954.
122. SMITH, N. J., FERTIG, S. N., and CURTIS, L. E. 1953 observations on yellow rocket control in established clover and alfalfa fields. Noeast. Weed Control Conf. Proc. 8:351–354. 1954.

123. SMITH, R. J. Let us spray. Soybean Digest 15(6):8–9. Apr. 1955.
124. ————. The response of soybeans to selected pre-emergence and post-emergence herbicides. Diss. Abs. 15:666–667. May 1955.
125. SORIANO, J. D. Weeds in the rice fields of Iloilo. Soil Sci. Soc. Philippines. J. 7:84–89. Second Q. 1955.
126. STAINIER, L. Le desherbage selectif des cultures de pois au moyen du dinitro-o-2-butyl-phenate ammonique. Cong. Internatl. de Phytopharm (Compt. Rend.) 3(2):751–755. 1952, pub. 1954.
127. STANIFORTH, D. W. Corn. No. Cent. Weed Control Conf. Res. Rpt. 11:62–66. 1954.
128. STAMPER, E. R., and CHILTON, S. J. P. Recommendations for the control of Johnson grass and other weeds in sugarcane. Sugar B. 33:142–144. Feb. 15, 1955.
129. ————, and ————. Weed control in sugarcane. Amer. Soc. Sugar Cane Technol. Proc. 4:12–16. 1950., pub. 1955.
130. ————, and ————. Weed control in Louisiana sugarcane. Sol Weed Conf. Proc. 8:207–210. 1955.
131. STANIFORTH, D. W., and WEBER, C. R. Effect of various weed infestations on the growth and yield of soybeans. Agron. Abs. 46:97. 1954.
132. STAPP, C., and SPICHER, G. Untersuchungen uber die wirkung von 2,4–D im boden. IV. Flavobacterium peregrinum n. sp. und seine fahigkeit zum abbau des hormones. Zentbl. f. Bakt. Parasitenk. Infekkrank. u. Hyg. Abt. II, 108:113–126. Ref. Sept. 20, 1954.
133. STEWART, M. J. A survey of chemical weed control in sugar cane. So. African Sugar J. 39: 395, 397, 399, 401, 403, 405, 407. Ref. June 1955.
134. SWEZEY, A. W., and FISHER, J. R. The control of annual grasses in California cotton with dalapon. Down Earth 2;2–5. Summer 1955.
135. SYMONS, J. L. Weed control in cereals. New Zeal. J. Agr. 91:49–51. July 15, 1955.
136. TAFURO, A. J., BEATTY, R. H., and JACK, C. C. The effect of six herbicides on alfalfa and clovers underseeded to spring oats. Noeast. Weed Control Conf. Proc. 8:307–311. 1954.
137. THOMPSON, J. C. Witchweed seed commits "suicide". (In Afrikaans) Landbouweekblad 36(1840): 35, 37. Oct. 20, 1954.
138. THOMPSON, J. T., HAUSER, E. E., and Stacy, S. V. Progress report on weed control in peanuts. Ga. Expt. Sta. L. 5,3 p. Jan. 1955.
139. TOLNER, J. Control of grasslike weeds in field crops. (In Dutch) Nieuwe Veldbode 21:728–729. June 16, 1955.
140. TREVETT, M. F. The effect of spray volume and rate of dinitro herbicide (DNOSBP) on weed control and clover stand in underseeded oats. Noeast. Weed Control Conf. Proc. 9:407–415. 1955.
141. ————, and CUNNINGHAM, C. Chemical weed control in small grains underseeded to legumes. Noeast. Weed Control Conf. Proc. 8:319–321. 1954.
142. UPCHURCH, R. P. Field experiments conducted in North Carolina during 1953 and 1954 relating to weed control in peanuts. So. Weed Conf. Proc. 8:110–117. Ref. 1955.
143. ————. Field experiments conducted in North Carolina during 1953 and 1954 relating to weed control in soybeans. So. Weed Conf. Proc. 8:162–170. Ref. 1955.
144. VEATCH, C. Control of weeds in corn by pre-emergence, emergence and post-emergence treatments. Noeast. Weed Control Conf. Proc. 9:265–270. 1955.
145. VELASCO, J. R. Some aspects of weeds in rice fields and their control. Philippines. Bur. Plant Indus. Plant Indus. Digest 17(4/5):83–86. Apr./May 1954.
146. VENGRIS, J. Chemical weed-control in field corn. Noeast. Weed Control Conf. Proc. 9:271–274. 1955.
147. ————. Downy chess (*Bromus tectorum*) control in alfalfa. Noeast. Weed Control Conf. Proc. 9:301–303. 1955.
148. ————, and COLBY, W. G. Chemical weed control in new grass-legume seedlings. Noeast. Weed Control Conf. Proc. 9:305–311. 1955.

149. WARREN, L. E. The control of annual grasses in sugar beets with dalapon. Amer. Soc. Sugar Beet Technol. Proc. 8(1):124–129. 1954,
150. WAYWELL, C. G. The effect of herbicidal treatments on oats. Noeast. Weed Control Conf. Proc. 9:391–397. 1955.
151. WHEATLEY, J. R., and WELLS, W. W. 1954 trials with "CRAG" herbidide–1 (SES) on peanuts. So. Weed Conf. Proc. 8:123–126. 1955.
152. WILCOX, M., and KUHN, A. O. A field study on rates and dates of applying certain chemicals for control of weeds in alfalfa. Noeast. Weed Control Conf. Proc. 8:341–350. 1954.
153. ————, and ————. A field study of rates and dates of applying certain chemicals for control of weeds in alfalfa. Md. Agr. Expt. Sta. Misc. P. 187: 10 p. 1953?
154. WILLARD, C. J. Chemical weed control in field crops. Ohio Agr. Col. Ext. B. 337, 16 p. Mar. 1953.
155. WILTON, A. C. Herbicides for forage crops. (Abs.) Brit. Columbia Agron. Assoc. Conf. Rpt. 1955.
156. WITMAN, E. D. A review of progress in weed control in cotton. So. Weed Conf. Proc. 8:25–30. 1955.

Weeds in horticulture, ornamental and vegetable crops

1. ALBAN, E. K. Some environmental factors which influence the use of DNBP with sweet corn, lima and snap beans. No. Cent. Weed Control Conf. Proc. 11:80–81. 1954.
2. ————. Chemical weeding of onions. No. Cent. Weed Control Conf. Proc. 11:75–76. 1954.
3. ————. Chemical weeding of vegetables. 1955. Ohio Veg. & Potato Growers Assoc. Annu. Proc. 40:49–58. 1955.
4. ————. Weeding asparagus with chemicals. No. Cent. Weed Control Conf. Proc. 11:77–78. 1954.
5. ALDRICH, R. J. Results with post emergence applications of DNOSBP in sweet corn. Noeast. Weed Control Conf. Proc. 8:209–210. 1954.
6. ————, and CAMPBELL, J. C. Chemicals applied pre- and postemergence for controlling weeds in potatoes. Noeast. Weed Control Conf. Proc. 9:239–243. 1955.
7. BING, A. Gladiolus weed control experiments 1953. Noeast. Weed Control Conf. Proc. 8:153–159. 1954.
8. ————. Gladiolus weed control experiments 1954. Gladiolus 30:78–84. 1955.
9. BIVINS, J. L., and KOFRANEK, A. M. Vapam weed control in Cymbidium beds. Amer. Orchid Soc. B. 24:467–468. July 1955.
10. BOWEN, T. J. Urea sprays in apples. Queensland Fruit & Veg. News 7:157–159. Feb. 3, 1955.
11. BRYANT, D. Count on chemicals for weed control. Wallaces' Farmer & Iowa Homestead 80(7):14. Apr. 2, 1955.
12. CARLSON, R. F. Grass control in red raspberries. Mich. Agr. Expt. Sta. Q. B. 37:349–353. Feb. 1955.
13. ————, and DANIELSON, L. L. Use a chemical hoe for controlling weeds. Amer. Fruit Grower. West. Ed. 75(4):52, 54–55. Apr. 1955.
14. ————, and GRIGSBY, B. H. Weed control in established asparagus plantings with CMU (3–(p–chlorophenyl)–1, 1–dimethylurea). Noeast. Weed Control Conf. Proc. 8:73–76. 1954.
15. CLARK, R. M. Does the use of growth regulators pay? Iowa State Hort. Soc. Proc. 88:76–79. 1953, pub. 1954.
16. COBB, J. S. Chemical weed control in potatoes. Noeast. Weed Control Conf. Proc. 9:255–256. 1955.
17. CROSSLEY, J. H. Experiments in weed control with herbicides in bulb crops at Saanichton. Nowest. Bulb Growers Assoc. Proc. Bulb Growers Short Course 1955:28–29.
18. CUNNINGHAM, C. E., and TREVETT, M. F. Chemical weed control in potatoes. Noeast. Weed Control Conf. Proc. 8:177–182. 1954.
19. DALLYN, S. The effect of repeated applications of Alanap-1 on cucumbers. Noeast. Weed Control Conf. Proc. 8:91–93. 1954.

20. DALLYN, S. L., SAWYER, R. L., HALIBURTON, T. H., and SEIF, R. D. Weed control in Sweet Spanish onions. Noeast. Weed Control Conf. Proc. 9:161–168. 1955.
21. DANIELSON, L. L. Comparison of granular and spray applications of herbicides on vegetable crops. Noeast. Weed Control Conf. Proc. 9:89–95. 1955.
22. ————, and HOFMASTER, R. N. Compatibility of mixtures of chemical weed-killers and insecticides applied to sweet corn plantings. Noeast. Weed Control Conf. Proc. 8:107–109. 1954.
23. ————, and SCHUMACHER, M. H. Experimental use of Dalapon and Natrin on certain transplanted vegetable crops. Noeast. Weed Control Conf. Proc. 9:97–103. 1955.
24. DAVIDSON, J. H., and RIES, S. K. Preliminary report on the control of quackgrass (*Agropyron repens*) and annual weeds in Michigan asparagus plantings. Noeast. Weed Control Conf. Proc. 9:131–136. 1955.
25. ————, WARREN, L. E., and FISHER, J. R. Preliminary reports on the use of dalapon in fruit planting. Down Earth 10(4):22–23. Spring 1955.
26. DAVIS, B. H., and BEATTY, R. H. Pre-emergence control of weeds in home vegetable gardens. Noeast. Weed Control Conf. Proc. 8:145–151. 1954.
27. DAY, B. E. Urea herbicides for citrus weed control. Calif. Citrog. 40:398, 408, 410–412, 414. Sept. 1955.
28. ————. Urea herbicides for citrus weed control. Citrus Leaves 35(9): 6–7, 14, 26, 28, 31. Sept. 1955.
29. DUDLEY, E. A. Weed control in home gardens. Calif. Farmer, South Ed. 203: 28–29. July 9, 1955.
30. ELLISON, J. H., and DALLYN, S. L. Effect of irrigation and cultivation on pre-emergence weed control of potatoes on Long Island. Noeast. Weed Control Conf. Proc. 8:159–161. 1954.
31. FERGUSON, W., and JASMIN, J. J. Chemical weed control in onion, squash and tomatoes. Noeast. Weed Control Conf. Proc. 9:169–175. Ref. 1955.
32. FINN, T. P., KING, L. J., and VLITOS, A. J. CRAG herbicide-I (sodium 2-(2,4-dichlorophenoxyethyl sulfate) for preventing weeds in flowers, shrubs and nursery stock. Noeast. Weed Control Conf. Proc. 8:239–249. 1954.
33. FLETCHER, R. G. T. Orchard weed control by spraying. Com. Grower 3066:646. Oct. 1, 1954.
34. FORSHEY, C. G. Excessive cultivation can reduce grape yields—a place for chemical weed control. Down Earth 10(4):19–21. Spring 1955.
35. GOPAL, R. Chemical control of weeds. Indian Farming 4(10):23–25. Jan. 1955.
36. GRIGSBY, B. H., and RIES, S. K. Combinations of chemicals for weed control in onions. No. Cent. Weed Control Conf. Proc. 11:72–73. 1954.
37. ————, and WILTSE, M. G. Weed control in potatoes by pre-emergence sprays. No. Cent. Weed Control Conf. Proc. 11:76–77. 1954.
38. GUZMAN, V. L., and WOLF, E. A. Chemical weeding of cabbage in muck soils. So. Weed Conf. Proc. 8:335–343. 1955.
39. ————, and WOLFE, E. A. Weed control in onions in the organic soil of the Florida Everglades. Weeds 3:66–74. Ref. Jan. 1954.
40. ————, and WOLF, E. A. Weeding lettuce and endive with CIPC in muck soil. So. Weed Conf. Proc. 8:344–348. 1955.
41. HAMMARLUND, A. Chemical control of weeds in nurseries and gardens. (In Danish) Gart.-Tid. 71:217–218. May 6, 1955.
42. HANTEN, H. Praktische unkrautbekampfung mit Crag-herbicide I. Klosterneuburg. Hohere Bundeslehr- u. Versanst. f. Wein- u. Obstbau. Mitt. Ser. B., Obst u. Gart. 5:145–146. June 1955.
43. HEMPHILL, D. D. Chemical weed control in vineyards. No Cent. Weed Control Conf. Proc. 11:82–83. 1954.
44. ————. Fruits. No. Cent. Weed Control Conf. Res. Rpt. 11:117–118. 1954.
45. HERRERA SOTO, J. M. Contribucion al conocimiento de la accion de herbicidas sobre malezas resistentes. Cacao en Colombia 3:123–140. 1954.

46. HITZ, C. W., CANN, J. P., and HOLMBERG, B. The control of strawberry runner growth by growth inhibiting chemicals. Amer. Soc. Hort. Sci. Proc. 64:263–273. Dec. 1954.
47. HOLM, L., and GILBERT, F. A. Weed control in apple and cherry orchards. No. Cent. Weed Control Conf. Proc. 11:83–84. 1954.
48. JONES, L. G., SISTRUNK, W. A., KING, J. R., and MILLER, J. C. Response of southern-grown potatoes to maleic hydrazide. (Abs.) Assoc. South. Agr. Workers. Proc. 52:121. 1955.
49. KATES, A. H. A comparison of various herbicides on sweet corn grown under both irrigated and non-irrigated conditions, 1953. Noeast. Weed Control Conf. Proc. 8:203–208. 1954.
50. ———. Chemical weed control in asparagus in newly set beds and older established beds, 1953. Noeast. Weed Control Conf. Proc. 8:63–67. 1954.
51. KAYS, W. R., and KECK, D. Chemical control of crab grass (*Digitaria*) in strawberry plantings. Okla. Agr. Expt. Sta. Mimeo. C. M–264, 5 p. Oct. 1954.
52. KLINGBEIL, G. C. Chemical weed control for fruit growers. Wis. Agr. Col. Ext. Spec. C. 38, 4 p. Feb. 1955.
53. KRAMER, J. A., and KING, L. J. Further studies with CRAG herbicides 1 (SES) on ornamentals and nursery stock. Noeast. Weed Control Conf. Proc. 8:211–213. 1954.
54. KUNTZ, J. E., and RIKER, A. J. Control of weed and grass competition in forest plantations. No. Cent. Weed Control Conf. Proc. 11:116–117. 1954.
55. LACHMAN, W. H. Pre-emergence weeding of squash. Noeast. Weed Control Conf. Proc. 9:193–194. 1955.
56. ———. Pre-emergence weeding of sweet corn. Noeast. Weed Control Conf. Proc. 9:111–113. 1955.
57. ———. Some observations on the use of Alanap–1 on vine crops. Noeast. Weed Control Conf. Proc. 8:89. 1954.
58. ———. Weeding sweet corn with Premerge. Noeast. Weed Control Conf. Proc. 8:95–96. 1954.
59. LANING, E. R. Weed control in cane berries and strawberries. Oreg. State Hort. Soc. Proc. 46:73–74. 1954.
60. ———. Weed control in pole beans & sweet corn. Mkt. Growers J. 84(3):40–41. Mar. 1955.
61. ———, and APPLE, S. B. Weed control in pole beans and sweet corn with dinitro amine in 1954. Down Earth 2:13–14. Summer 1955.
62. LARMIE, W. E. Chemical weed control in Gladiolus. Gladiolus 30:138–144. 1955.
63. LYERLY, P. J., and STITH, L. S. Control of early weeds in the El Paso Valley, 1954. Tex. Agr. Expt. Sta. Prog. Rpt. 1779, 2 p. Apr. 15, 1955.
64. MAHLSTEDE, J. P. Chemical weed control in nursery crops. Iowa State Hort. Soc. Proc. 88:174–176. 1953, pub. 1954.
65. ———. Chemical weed control in the nursery. Amer. Nurseryman 101(8):11–13, 100–106. Ref. Apr. 15, 1955.
66. ———. Herbaceous weeds in woody crop plants and flowers including forest nurseries, ornamental nurseries, shelterbelts, and all others. No. Cent. Weed Control Conf. Res. Rpt. 11:119–123. 1954.
67. MARSHALL, E. R., and CURTIS, L. E. Weed control in peas with various herbicides. Noeast. Weed Control Conf. Proc. 8:131–135. 1954.
68. ———, and FERRANT, N. A. Preliminary results with several new herbicides applied to asparagus plantings. Noeast. Weed Control Conf. Proc. 8:59–62. 1954.
69. MASSACHUSETTS UNIVERSITY AGRICULTURAL EXTENSION SERV. 1955 cranberry weed control chart, 16th. Amherst, 1955.
70. MCWHORTER, C. G., and WATSON, W. W. A progress report on the use of several herbicides for weed control in spinach. So. Weed Conf. Proc. 8:326–334. 1955.
71. MENGES, R. M., and ALDRICH, R. J. A comparison of CRAG, derivatives of CRAG, and CMU for pre-emergence weed control in tomatoes. Noeast. Weed Control Conf. Proc. 8:137–143. 1954.

72. MICHIGAN STATE COLLEGE OF AGRICULTURE AND APPLIED SCIENCE. EXTENSION SERV. Chemical weed control in small fruits and orchards. Mich. State Col. Agr. Ext. Folder F-190, 8 p. Feb. 1955.
73. ————. Chemical weed control in vegetable crops. Mich. State Col. Agr. Ext. Folder F-193, 10 p. Mar. 1955.
74. MOORE, E. L. Some effects of certain growth-regulating substances upon premature seeding in cabbage. Miss. Agr. Expt. Sta. Tech. B. 40, 42 p. Ref. Mar. 1955.
75. MOORE, J. F., and WOLFE, H. H. Chemical weed control in beans for western Washington. Wash. State Col. Ext. Misc. P. 34, 4 p. Mar. 1955.
76. ————, and ————. Chemical weed control in pickling cucumbers for western Washington. Wash. State Col. Ext. Misc. P. 35, 3 p. Mar. 1955.
77. MORRIS, H. E., and SHAW, A. F. Perennial weeds and their control. Mont. State Col. Ext. B. 225, rev., 44 p. Dec. 1954.
78. NOLL, C. J., and ODLAND, M. L. Chemical herbicides as they effect yield of tomatoes. Noeast. Weed Control Conf. Proc. 8:191–192. 1954.
79. ————, and ————. Chemical weeding of lima beans. Noeast. Weed Control Conf. Proc. 8:183–185. 1954.
80. ————, and ————. Weeding of cannery peas with herbicides. Noeast. Weed Control Conf. Proc. 8:127–130. 1954.
81. ————, and ————. Weeding of seeded onions with chemicals. Noeast. Weed Control Conf. Proc. 8:187–189. 1954.
82. ————, and ————. Weeding of seedling asparagus in a pre-emergence application. Noeast. Weed Control Conf. Proc. 8:55–58. 1954.
83. ————, and ————. Weed control in lima beans with various herbicides. Noeast. Weed Control Conf. Proc. 9:183–186. 1955.
84. ————, and ————. Weed control in set onions with pre-emergence and post-emergence application of herbicides. Noeast. Weed Control Conf. Proc. 9:157–159. 1955.
85. NORDBY, A. Spraying in nurseries. (In Norwegian) Gartneryrket 45:39–43. Jan. 21, 1955.
86. ORSAT, C. O. La vigne et les hormones de desherbage. Rev. Agr. de l'Afrique du Nord 52:119–124. (Cont.) Jan. 29, 1954.
87. PALTI, J., and NITZANY, F. Chemical treatment of solanaceous vegetables. (In Hebrew) Hassadeh 15:525–527. Apr. 1955.
88. PAPAI, M. J., BARAN, W., and MARSHALL, E. R. Experimental trials and grower usage of herbicides on muck grown onions in New York State in 1954. Noeast. Weed Control Conf. Proc. 9:151–155. 1955.
89. PASS, H. A., and ZEDLER, R. J. Experimental herbicide Natrin 8OS for weed control in tomatoes, tobacco & other transplanted crops. Canada. Natl. Weed Comt. East. Sect. Proc. 8:38–39. 1954, pub. 1955.
90. PATTERSON, C. F. 2,4–D, friend and foe. Winnipeg Flower Gard. 1954:31, 33, 35–38.
91. PEABODY, D. V. Weed control experiments in Washington (1953–1954). Nowest. Bulb Growers Assoc. Proc. Bulb Growers Short Course 1955:29–30.
92. PENNSYLVANIA AGRICULTURAL EXPERIMENT STATION. Weed control in potatoes, 1953 treatments. Noeast. Weed Control Conf. Proc. 8:165. 1954.
93. PERKINS, D. Y. Post-emergence weed control in muck grown seeded onions. Noeast. Weed Control Conf. Proc. 8:115–117. 1954.
94. ————. Pre-emergence weed control in muck grown seeded onions. Noeast. Weed Control Conf. Proc. 8:111–114. 1954.
95. PRIDHAM, A. M. S. Artemisia vulgaris-control in nursery plants. Noeast. Weed Control Conf. Proc. 8:233–234. 1954.
96. ————. Fall application of herbicides in nurseries. Noeast. Weed Control Conf. Proc. 8:227–229. 1954.
97. ————. Fall applications of herbicides in nurseries. Noeast. Weed Control Conf. Proc. 8:231–232. 1954.
98. PROEBSTING, E. L. The use of weed sprays in orchard soil management. Wash. State Hort. Assoc. Proc. 50:158–160. 1954.

99. PUTTUSWAMY, H. S. Notes on weeds commonly found in coffee estates in Mudigere zone. Indian Coffee 19:104–105. May 1955.
100. PY, C. Le C.M.U. herbicide selectif hautement efficace pour plantation d'ananas. Fruits 10:157–161. Apr. 1955.
101. RAHN, E. M. Alanap-l as a herbicide for vine crops in 1953. Noeast. Weed Control Conf. Proc. 8:83–87. 1954.
102. ———. CMU-value for weed control and effect on yields of asparagus. Noeast. Weed Control Conf. Proc. 8:69–71. 1954.
103. REBOUR, H. La destruction du chiendent dans les vergers cultives en sec. Rev. Agr. de l'Afrique du Nrod 53:395–396. Apr. 1, 1955.
104. RIEPMA, P. Onkruidbestrijding in veld- en stambonen en in lupine (Control of weeds of kidney beans and field beans and of lupines). Tech. Ber. 66, 4 p. Mar. 1955.
105. RIES, S. K. Spray away your weed troubles. Amer. Veg. Grower 3(5):8–9, 26. May 1955.
106. ———, and GRIGSBY, B. H. Post emergence application of herbicides on tomatoes. No. Cent. Weed Control Conf. Proc. 11:79–80. 1954.
107. ———, and ———. Pre and post emergence weed control in sweet corn. Noeast. Weed Control Conf. Proc. 9:105–109. 1955.
108. ROBINSON, J. B. D. Report on the progress made with chemical control of weeds in coffee. Coffee Bd. Kenya. Mon. B. 19:204–208. Sept. 1954.
109. ———. Second progress report on chemical control of weeds in coffee. Coffee Bd. Kenya. Mon. B. 20:151–152,160. June 1955.
110. SABUROVA, P. V. Utilization of mineral oils for weed control in carrot plantings. (In Russian) Leningrad. Vsesiuzn. Inst. Zashch. Rast. Trudy 5:155–163. Ref. 1954.
111. SAWYER, R. L., and DALLYN, S. L. Pre-emergence herbicides and cultivation for weed control in potatoes. Noeast. Weed Control Conf. Proc. 9:227–229. 1955.
112. SCHREIBER, M. M., and FERTIG, S. N. Second year effects of various herbicides on the yield and botanical composition of legumes. Noeast. Weed Control Conf. Proc. 9:313–323. 1955.
113. SCOTT, D. H., SHAW, W. C., and RUPPENTHAL, R. U. Evaluation of several chemicals for weed control in strawberry fields. Weeds 3:192–207. Ref. Apr. 1954.
114. STAALDUINE, D. VAN. Control of weeds of onions and leek. (In Dutch) Groenten en Fruit 10:1149. May 19, 1955.
115. STANDEN, J. H. Recent developments with the two contact herbicides, Good-rite N.I.X. and Good-rite Oktone in greenhouse, nursery, and truck crop work. Noeast. Weed Control Conf. Proc. 8:235–237. 1954.
116. SWEET, R. D. Chemicals for weeding tomatoes. Farm Res. (N. Y. Sta.) 21 (2):12. Apr. 1955.
117. ———. The effect of certain environmental factors on the response of sweet corn to herbicides. Noeast. Weed Control Conf. Proc. 8:97–105. 1954.
118. ———. Weeding vegetables with chemicals. Veg. Growers Assoc. Amer. Annu. Rpt. 1954:133, 135, 137, 139, 141, 143, 145–148.
119. ———, and CAREW, J. Chemical weeding of peas. Cornell Veg-News 6(2):3–4. Apr. 15, 1955.
120. SWEET, H. A., and MARSHALL, E. R. Post-setting and lay-by applications of herbicides to canning tomatoes in western New York. Noeast. Weed Control Conf. Proc. 9:115–119. 1955.
121. SWEET, R. D., CRABTREE, G., and BENEDICT, C. Herbicides for tomatoes. Noeast. Weed Control Conf. Proc. 9:141–149. 1955.
122. ———, ———, and ———. Response of squashes to ALANAP–1. Noeast. Weed Control Conf. Proc. 9:195–199. 1955.
123. THOMPSON, J. T., HAUSER, E. W., and STACY, S. V. Three years results on the use of chemicals to control weeds in peanuts under Georgia conditions. So. Weed Conf. Proc. 8:118–122. 1955.
124. TICKNOR, R. L., and BOBULA, P. F. Some results with pre-emergence applications of several herbicides around Rhododendrons and Taxus. Noeast. Weed Control Conf. Proc. 9:211–215. 1955.

125. TREVETT, M. F., MURPHY, H. J., and BRADBURY, H. E. Pre-emergence weeding sweet corn with 2,4–D, dinitro, and isopropyl trichlorobenzoic acid. Noeast. Weed Control Conf. Proc. 8:193–201. 1954.
126. TURNQUIST, O. C. Control of quack grass in vegetable gardens. No. Cent. Weed Control Conf. Proc. 11:81–82. 1954.
127. WARREN, G. F. Vegetables. No. Cent. Weed Control Conf. Res. Rpt. 11:103–116. 1954.
128. ————. Weed control in onions with CIPC. No. Cent. Weed Control Conf. Proc. 11:71. 1954.
129. WASHINGTON STATE COLLEGE EXTENSION SERV. Spraying apricots with 2,4,5–T affects the size, maturity and drop of fruit. Wash. State Col. Ext. Mimeo. 1685, 2 p. 1955.
130. WHITE, R. G. Control of weeds and woody growth in lowbush blueberry plantations. Canada Natl. Weed Comt. East. Sect. Proc. 8:57–61. 1954. pub. 1955.
131. WILLARD, C. J. Additional chemical weed control suggestions, 1955. Ohio Agr. Col. Ext. L. L-50, 4 p. Mar. 1955.
132. WILLIS, S. J. Weed control in farm and garden. London, Vinton, 1954. 184 p. (Agricultural and Horticultural Students Series)
133. ————. Modern herbicidal developments in horticulture. Nech. Hort. 3:48–50. Ref. Spring 1955.
134. WILLS, J. M., and WALLACE, J. Weed control in bananas. Queensland Fruit & Veg. News 7:181. Feb. 10, 1955.
135. ————, and ————. Weed control in bananas. Banana B. 18(4):6–7. Apr. 1955.
136. WINDEN, W. P. VAN, and STAALDUINE, D. VAN. Use of chemical herbicides in horticultural weed control. (In Dutch) Groenten en Fruit 10:608. Dec. 23, 1954.
137. WOLF, E. A., and GUZMAN, V. L. A summary of weed control experiments in sweet corn on the organic soils of the Florida Everglades 1952–1954. So. Weed Conf. Proc. 8:349–356. 1955.

Weeds in grasslands (pastures, etc.)

1. ALBERT, W. B. Chemical weed control in establishing coastal Bermuda grass (*Cynodon dactylon*) So. Weed Conf. Proc. 8:222–225. 1955.
2. ALDER, F. E. Selective weed control in direct-sown leys. Gr. Brit. Min. Agr. Agriculture. May 1955.
3. ALLEN, H. P. Weed control in grassland. Cong. Internatl. de Phytopharm (Compt. Rend.) 3(2):689–698. 1952, pub. 1954.
4. BOHMONT, D. Weeds in Pandora's box? Wyo. Roundup 3:7. July 1955.
5. DAVIDSON, J. H. Turf renovation using Dowfume MC–2 with no cultivation. Down Earth 10(4):8–9. Spring 1955.
6. GRIGSBY, B. H. Turf. No. Cent. Weed Control Conf. Res. Rpt. 11:99–102. 1954.
7. HAUSER, E. W., THOMPSON, J. T., and CROWDER, L. V. Progress report on chemical weed control in sprigged Coastal Bermuda grass (*Cynodondactylon*). So. Weed Conf. Proc. 8:217–221. 1955.
8. HILE, J. R. Chemical lawn care. Seed World 75(12):30–31. Dec. 17, 1954.
9. HUNT, J. L. The control of weeds in grassland. II. Agr. Merchant 35:134–136. Mar. 1955.
10. JAGSCHITZ, J. A., and CORNMAN, J. F. Comparison of 4 chloro, 3,4–D, MCP, 2,4,5–T in various formulations for the control of white clover in turf. Noeast. Weed Control Conf. Proc. 9:371–374. 1955.
11. ————, and ————. Persistence of clover control in putting green turf treated with Endothal and 2,4,5–T. Noeast. Weed Control Conf. Proc. 9:375–383. 1955.
12. ————, and ————. Studies in the control of *Veronica filiformis* in turf using KOCN, Endothal, 2,4–D and 2,4,5–T. Noeast. Weed Control Conf. Proc. 9:365–369. 1955.
13. JOHNSON, C., PEABODY, D. V., and WOLFE, H. H. Annual weed control in western Washington pasture and hay seedings. Wash. State Col. Ext. Misc. P. 33, 4 p. Mar. 1955.

14. McCarty, M. K. Herbaceous weeds in pastures and meadows. No. Cent. Weed Control Conf. Res. Rpt. 11:92–94. 1954.
15. ————. No excuse for weedy pastures; one treatment lasts all summer, buckbrush also controlled. Successful Farming 53(6):40–41,72. June 1955.
16. McFaul, J. A. Two years' test and demonstration work in turf renovation using calcium cyanamid. Noeast. Weed Control Conf. Proc. 9:341–343. 1955.
17. Nave, Z. Chemical control of undesirable plants in natural pasture. (In Hebrew) Hassadeh 35:478–483. Mar. 1955.
18. Paixao, J. Da C. Chemical control of pasture weeds. (In Portuguese) Selec. Agr. 10(105):51–53. Jan. 1955.
19. ————. Chemical control of pasture weeds. (In Portuguese) Coop. Cent. des Prod. de Leite. B. da C.C.P.L. 8:62,42. Feb. 1955.
20. Scott, W. O., and Slife, F. W. Chemical control of weeds and brush. Ill. U. Agr. Ext. C. 742, 12 p. May 1955.
21. Sprague, M. A. Further investigations with chemicals in pasture renovation. Noeast. Weed Control Conf. Proc. 8:377–379. 1954.
22. ————, and Kates, A. H. Pasture renovation with herbicides. Natl. Fert. Rev. 30:14–16. Jan./Mar. 1955.
23. ————, and ————. Pasture renovation with herbicides. Tex. Livestock J. 14(5):6–7. May 15, 1955.
24. Zonderwijk, P. Control of weeds in grassland with the aid of growth substances. (In Dutch) Drents Landbbl. 36(20):6. May 19, 1955.

Weeds in specialized areas (ditches, etc.)

1. Chadwick, L. C., and Barker, P. A. Chemical weed control in deciduous and evergreen nursery stock. No. Cent. Weed Control Conf. Proc. 11:86–88. 1954.
2. ————, and ————. Chemical weed control in Taxus. No. Cent. Weed Control Conf. Proc. 11:84–86. 1954.
3. Cohen, G. Chemical control of weeds in moist soil. (In Hebrew) Hassadeh 35:217–218. Jan. 1955.
4. Curtis, D. V., Iurka, H. H., Muller, E. W., Secor, E., and Ward, D. Herbicide work on New York State highways. Noeast. Weed Control Conf. Proc. 9:463–470. 1955.
5. Davidson, J. H. Highway vegetation control with chemicals. Purdue U. Engin. Ext. Dept. Ext. Ser. 86:104–111. Apr. 19/22, 1954.
6. Deakin, O. A. Preventive weed control along New Jersey highways and parkways. Noeast. Weed Control Conf. Proc. 8:517–519. 1954.
7. Derscheid, L. A. Perennial weed control. No. Cent. Weed Control Conf. Proc. 11:120–122. 1954.
8. Evans, S. Weed control on state highways. Natl. Shade Tree Conf. Proc. 30:241–246. 1954.
9. Farley, J. L. Chemical control of roadside weeds and brush. Pub. Works 86(4):80. Apr. 1955.
10. Greene, W. C. The progress of weed control on Connecticut State highways. Noeast. Weed Control Conf. Proc. 9:429–432. 1955.
11. Grigsby, B. H., Reimer, C. A., and Cutler, W. A. Control of cattails in drainage ditches. Down Earth 10(4):14–15. Spring 1955.
12. Hall, V. L. Industrial weed control of railroads, irrigation districts, and industrial plants. Calif. Weed Conf. Proc. 7:104–108. 1955.
13. Lowry, O. J. Hot weeds. Reclam. Era 41:74–75. Aug. 1955.
14. McMahon, R. J. Public acceptance of chemical control of roadside vegetation. Noeast. Weed Control Conf. Proc. 9:53–57. 1955.
15. ————. Roadside spraying for weed control. Noeast. Weed Control Conf. Proc. 8:521–526. 1954.
16. Parris, C. G., and Rodgers, E. G. Weed control investigations on railroad rights-of-way. So. Weed Conf. Proc. 8:372–385. 1955.
17. Payne, H. Weed control on public utility properties. Calif. Weed Conf. Proc. 7:102–104. 1955.

18. PHILLIPS, W. M. Control of deep-rooted perennial weeds with 2,4–D–boron complexes and other soil sterilizing chemicals. No. Cent. Weed Control Conf. Proc. 11:44–46. 1954.
19. PRICE, L. N. Sussex County's highway weed-control program. Noeast. Weed Control Conf. Proc. 9:505–511. 1955.
20. SHAFER, N. E. Soil applications of 2,4–D for the control of deep-rooted perennial weeds. No. Cent. Weed Control Conf. Proc. 11:56–59. 1954.
21. SKRDLA, W. Herbicides and soil sterilants for grounds maintenance. Agron. Abs. 47:82. 1955.
22. STEENIS, J. H. Weed control in marshes. Noeast. Weed Control Conf. Proc. 9:513–517. 1955.

Woody plants

1. ARNOLD, J. F. Juniper control. Ariz. Cattle-log 10(9):44–50. May 1955.
2. BEATTY, R. H. Control of brush on roadsides, utility lines and other rights of way. No. Cent. Weed Control Conf. Res. Rpt. 11:128. 1954.
3. ———. Right of way clearance with chemicals. Calif. Weed Conf. Proc. 7:88–94. 1955.
4. BEHRENS, R. Mesquite control—problems associated with the control of mesquite by aerial application of chemicals. Tex. Agr. Aviation Conf. Papers 3:I1–I4. 1954.
5. BLEAK, A. T., and MILLER, W. G. Sagebrush (*Artemesia tridentata*) seedling production as related to time of mechanical eradication. J. Range Mangt. 8:66–69. Mar. 1955.
6. BOHMONT, D. W. It pays to stop sagebrush. Cow Country 82(8):12–14. Feb. 15, 1955.
7. ———, and ALLEY, H. P. Chemical control of big sagebrush (*Artemisia tridentata*); costs and results three years after chemical treatments. Wyo. Agr. Expt. Sta. Mimeo. C. 56, 9 p. Mar. 1955.
8. BOICE, F. S. A southwestern rancher's viewpoint of shrub (brush) control. Ariz. Cattlelog 10(7):20–24. Mar. 1955.
9. ———. A southwestern rancher's viewpoint of shrub control. J. Range Mangt. 8:103–104. May 1955.
10. BRAMBLE, W. C., and BYRNES, W. R. Effect of certain common brush control techniques and materials on game food and cover on a power line right-of-way No. 2. Pa. Agr. Expt. Sta. Prog. Rpt. 135, 7 p. Aug. 1955.
11. BURESCH SAGNER, O. La ciencia y la arboricultura: el uso de productos quimicos para la eliminacion de arboles. Chacra 24(291):50–51. Feb. 1955.
12. CALIFORNIA DEPT. OF NATIONAL RESOURCES. DIV. OF FORESTRY. Chemical brush control techniques on California range lands, by O. A. Leonard and C. E. Carlson. Rev. Sacramento, 1955.
13. COFFEY, W. J. Brush control—materials and methods. No. Cent. Weed Control Conf. Proc. 11:106–109. 1954.
14. COULTER, L. L. Some aspects of right-of-way brush control with 2,4,5–T and 2,4–D. Weeds 3:21–27. Jan. 1954.
15. CRUMPACKER, J. D., and LARSON, R. E. Report of a study of brush control methods and equipment. No. Cent. Weed Control Conf. Proc. 11:97–99. 1954.
16. DAHMS, W. G. Chemical brush control on central Oregon Ponderosa pine (*Pinus Ponderosa*) lands. U. S. Forest Serv. Pacific Nowest. Forest & Range Expt. Sta. Res. Note 109, 5 p. Feb. 1955.
17. ———, and JAMES, G. A. Brush control on forest lands with emphasis on promising methods for the Pacific Northwest (a review of selected references). U.S. Forest Serv. Pacific Nowest. Forest & Range Expt. Sta. Res. Paper 13, 80 p. Ref. May 1955.
18. DARROW, R. A. Aerial applications of herbicides in the control of brush and woodland. Tex. Agr. Aviation Conf. Papers 4:F1–F5. 1955.
19. ———. Chemical control of live oak and shin oak in the Edwards Plateau. So. Weed Conf. Proc. 8:269–272. 1955.
20. DEKATOV, N. Utilization of chemicals in brush clearing from land. (In Russian) Kolkhoz. Proizvodstvo 15:41–43. Jan. 1955.

21. DERSCHEID, L. A., and FERRELL, E. K. Chemical control of woody plants. S. Dak. Agr. Expt. Sta. C. 114,12 p. Apr. 1955.
22. ELDER, W. C. Better checkmates for brush. South. Seedsman 17(7):32. July 1954.
23. ELWELL, H. M. Control of brush on rangeland and pastures. No. Cent. Weed Control Conf. Res. Rpt. 11:124–127. 1954.
24. ———, and ELDER, W. C. Tests of aerial applications of herbicides on post oak (*Quercus stellata*) and blackjack brush (*Quercus marilandica*) in Oklahoma; progress report, 1954. Okla. Agr. Expt. Sta. Mimeo. C. M-268, 7 p. Apr. 1955.
25. ———, ———, KLINGMAN, D. C., and LARSON, R. E. Aerial applications of herbicides on oak in Oklahoma. No. Cent. Weed Control Conf. Proc. 11:91–95. 1954.
26. FISHER, C. E., and MEADORS, C. H. Why brush control? So. Weed Conf. Proc. 8:229–232. 1955.
27. FRYER, J. D. The role of arboricides in bush and forest eradication. J. Sci. Food & Agr. 6:73–78. Feb. 1955.
28. GLEASON, L. S., and LOOMIS, W. E. Basal sprays and injection treatments on trees. No. Cent. Weed Control Conf. Proc. 11:102–104. 1954.
29. HANSEN, H. L. Control of woody plants in forests, tree plantations and farm woodlands. No. Cent. Weed Control Conf. Res. Rpt. 11:129–136. 1954.
30. HAVILAND, S. A. New chemical sprays ease right-of-way clearance. Telephone Engin. & Managt. 59(4):55–59. Apr. 1955.
31. HOFFMAN, G. O. Brush control and proper range management pay. Soil & Water Mag. 4(3):28–30. Mar. 1955.
32. HYDER, D. N., and SNEVA, F. A. Effect of form and rate of active ingredient, spraying season, solution volume, and type of solvent on mortality of big sagebrush, *Artemisia tridentata*. Oreg. Agr. Expt. Sta. Tech. B. 35, 16 p. Apr. 1955.
33. JACKSON, S., and WHEELWRIGHT, G. Chemical brush control on the coast. Calif. Weed Conf. Proc. 7:22–23. 1955.
34. KENNEDY, B., and NICHOLS, B. Beat the brush with chemicals. Farm & Ranch—South. Agr. Dixie Ed. 85(2):16–17. Feb. 1955.
35. LEONARD, O. A. Some observations on new chemicals for woody plant control and some factors influencing success with cut-surface treatments for killing trees. Calif. Weed Conf. Proc. 7:94–100. 1955.
36. LOUGHEED, A. W. Railway brush spraying operations. Canada. Natl. Weed Comt. East. Sect. Proc. 8:40–41. 1954., pub. 1955.
37. MALECKI, R. V. How to eliminate hardwoods. Pulp & Paper 29(7):84–85. July 1, 1955.
38. MARTIN, S. C., and JONES, T. W. Some effects of basal and frill treatments of 2,4,5–T, ammate, and CMU on oaks. No. Cent. Weed Control Conf. Proc. 11:99–102. 1954.
39. MCCULLY, W. G. Chemical control of oak and mixed brush. Tex. Agr. Aviation Conf. Papers 3:J1–J6. 1954.
40. ———. Chemical control of whitebrush (*Aloysia lycioides*). So. Weed Conf. Proc. 8:260–264. 1955.
41. ———. Controlling trash timber and brush in pecan groves. Tex. Pecan Growers Assoc. Proc. 33:20–22. 1954.
42. MCILVAIN, E. H. Interim report on shinnery oak (*Quercus*) control studies in the Southern Great Plains. No. Cent. Weed Control Conf. Proc. 11:95–96. 1954.
43. MCMILLAN, F. W., MCKIBBEN, G. E., and BOGGESS, W. R. Controlling sassafras, persimmon, and elm with 2,4,5–T and mixtures of 2,4,5–T and 2,4–D. Ill. Agr. Expt. Sta. Forestry Note 58, 5 p. Aug. 10, 1955.
44. ———, ———, and ———. Results of 2,4,5–T applications in sycamore and willow. Ill. Agr. Expt. Sta. Forestry Note 60, 2 p. Aug. 16, 1955.
45. MEYERS, W. A., ALLEN, W. W., and BEATTY, R. H. Effect of ATA on woody plants. Noeast. Weed Control Conf. Proc. 9:445–450. 1955.
46. ———, ———, and ———. Report on two years results of dormant basal sprays on mixed brush. Noeast. Weed Control Conf. Proc. 8:453–458. 1954.

47. NAVEZ, R. Excursion dans la region de Couvin. Soc. Roy. Forest. de Belg. B. 62:199–205. Apr. 1955.
48. OWENS, C. B., and WILLARD, C. J. Chemical eradication of hawthorn (Crataegus). No. Cent. Weed Control Conf. Proc. 11:96–97. 1954.
49. PAGE, T. J. Two blades of grass; chemical brush killers promise to improve rangelands in the southwest by control of oak. Dow Diamond 18:5–7. Mar. 1955.
50. PARKER, K. G. Sagebrush control offers range improvement opportunities. Mont. Wool Grower 29(8):8. Aug. 1955.
51. PLAVSKII, V. I. Effectiveness of herbicides in controlling brush on meadows and pastures. (In Russian) Zhivotnovodstvo 12:114–117. Dec. 1954.
52. SCHULTZ, A. M., and BISWELL, H. H. Brush control with chemicals; hormone-type sprays tested for use in brushland management prove most effective when applied to current year seedlings. Calif. Agr. 9(5):5, 13. May 1955.
53. ————, and ————. Brush control with hormone-type sprays most effective on current year seedlings. Calif. Cattleman, June 1955.
54. SMITH, E. W. The brush control program of the Shawinigan Water & Power Co. Canada. Natl. Weed Comt. East. Sect. Proc. 8:46–49. 1954, pub. 1955.
55. THERRELL, J. S. Weeding the woodland. Miss. State Col. Ext. P. 301, 6 p.–folder. June 1955.
56. TIMMONS, F. L. Summary of recent research findings on control of submersed aquatic weeds in irrigation systems of the West. So. Weed Conf. Proc. 8:359–363. 1955.
57. TORELL, P. J. Chemical control of brush in Idaho. Idaho Farmer 73:84, 106. Feb. 3, 1955.
58. VINING, K. Brush control with chemicals. Prairie Farmer, Mich. Ed. 127(14):28–29. July 16, 1955.
59. WALKER, L. C. Weed tree problems in Piedmont pine stands. So. Weed Conf. Proc. 8:237–278. Ref. 1955.
60. WAYWELL, C. G. A progress report on the control of hawthorn (*Crataegus*) Noeast. Weed Control Conf. Proc. 8:431–434. 1954.
61. WHITE, C. W. A six-year summary of brush-control work in the Tennessee Valley region. So. Weed Conf. Proc. 8:237–239. 1955.
62. WILLARD, C. J., and OWENS, C. B. Hawthorn (*Crataegus*) can be eradicated by use of herbicides. Ohio Farm & Home Res. 40:69–70. July/Aug. 1955.
63. WORLEY, D. P., BRAMBLE, W. C., and BYRNES, W. R. The effect of volume, concentration and point of application of 2,4,5–T in the basal treatment of bear oak (*Quercus ilicifolia*). Noeast. Weed Control Conf. Proc. 9:439–444. 1955.

Aquatic weeds

1. CHIPMAN CHEMICAL ENGINEERING CO. Control weeds in ponds and lakes. Bound Brook, N. J., 1954.
2. CRAIG, A. L. Use of gasoline and chlorinated benzenes for killing submersed water weeds. So. Weed Conf. Proc. 8:368–371. 1955.
3. GOULD, J. D. Control of water weeds. N. Y. State Conserv. 9(6):11. June/July 1955.
4. HUCKINS, R. K. Aquatic weed control studies in New Jersey. Noeast. Weed Control Conf. Proc. 9:519–534. 1955.
5. KINSMAN, H. J. A. Water weed management. Country Gent. Estate Mag. 55:236–237. 1955.
6. MACKENTHUN, K. M. The control of submergent aquatic vegetation through the use of sodium arsenite. Noeast. Weed Control Conf. Proc. 9:545–555. Ref. 1955.
7. OBORN, E. T. Control of aquatic weeds that impede flow of western irrigation waters. Weeds 3:231–240. Ref. July 1954.
8. RIGG, H. H. The effect of herbicides on a series of aquatic plants. Noeast. Weed Control Conf. Proc. 9:535–544. 1955.
9. SAFRA, R., and KONIK, B. On measures for controlling dodder. (In Russian) Khlopkovodstvo 5(4):41–43. Apr. 1955.

10. SRINIVASAN, R., and CHACKO, P. I. Further experiments on the control of aquatic vegetation with "2,4–D". Indian Sci. Cong. Assoc. Proc. 42(3, abs.):317–318. 1955.
11. STEPHENS, J. C., CRAIG, A. L., and SEALE, C. C. Blended solvents for control of the submersed water weed naiad (*Naias guadalupensis*) in south Florida. Weeds 3:160-170. Apr. 1954.

Specific weeds

1. AKAMINE, E. K., and NAKASONE, H. Y. Control of weeds in orchid culture with special reference to the effect of CMU on *Oxalis corniculata L.* Amer. Orchid Soc. B. 23:808–814. Dec. 1954.
2. BAILEY, J. S. Control of poison ivy (*Toxicodendron radicans*) in the orchard. New Eng. Homestead 128(5):28–29. Mar. 12, 1955.
3. ———. Control of poison ivy and other orchard weeds. Mass. Fruit Growers' Assoc. Rpt. Annu. Mtg. 61:42–45. 1955.
4. BARNARD, R. C. The control of lalang (*Imperata arundinacea* var. major) by fire protection and planting. Malayan Forester 17–152–156. July 1954.
5. BELL, R. S., and BANNISTER, E. J. Chemical control of northern nutgrass (*Cyperus esculentus*) in potato fields. Noeast. Weed Control Conf. Proc. 9:231–234. 1955.
6. BISSET, W. J., and SHAW, N. H. A comparison of D.C.P.A., T.C.P.A., and arsenic for killing eucalypt regrowth in sub-tropical native pastures. Austral. Inst. Agr. Sci. J. 20:177–181. Sept. 1954.
7. BIVINS, J. L. Morning glory (Ipomoea) control in flowers and field crops. Calif. Weed Conf. Proc. 7:16–18. 1955.
8. BLOUCH, R. M. Grass-type weeds can be chemically controlled. Colo. A & M News 8(6):5. Dec. 1953.
9. BOGDAN, A., and STORRAR, A. The control of Aristida and other annuals in Kenya Rift Valley pastures. Empire J. Expt. Agr. 22:211–223. July 1954.
10. BOHMONT, D. W. It pays to stop sagebrush (Artemisia). Wyo. Roundup 2(2):6–7. Oct. 1954.
11. BRAGG, K. K. Investigations in the control of poison ivy. Canada Natl. Weed Comt. East. Sect. Proc. 8:89–95. 1954, pub. 1955.
12. BUCHHOLTZ, K. P. Dalapon and maleic hydrazide for control of quackgrass. No. Cent. Weed Control Conf. Proc. 11:62–63. 1954.
13. ———. Quackgrass. No. Cent. Weed Control Conf. Res. Rpt. 11:1–9. 1954.
14. BURT, E. O. Control of nutgrass (*Cyperus rotundus* L.) with herbicides and tillage. So. Weed Conf. Proc. 8:405–408. 1955.
15. CAMPAGNA, E. Ragweed (*Ambrosia artemisifolia*) survey and eradication in Prince Edward Island. Canada Natl. Weed Comt. East. Sect. Proc. 8:76–83. 1954, pub. 1955.
16. CARLSON, R. F. Fall applications with CIPC on three strawberry varieties for control of common chickweed (*Stellaria media*). Noeast. Weed Control Conf. Proc. 9:221–222. 1955.
17. ———. Grass control in red raspberries. Noeast. Weed Control Conf. Proc. 9:217–220. 1955.
18. CARVELL, R. L., and TRYON, E. H. Wild grape vines—they can be controlled. W. Va. Agr. Expt. Sta. B. 369(3):3,8. Spring 1955.
19. COHEN, G. Destruction of Sorghum halepense. (In Hebrew) Hassadeh 35:664–665. May 1955.
20. COULTER, L. L. Experiments with Dalapon in controlling several grass problems of railroads. Noeast. Weed Control Conf. Proc. 8:477–481. 1954.
21. DANIEL, W. H. Arsenic control of *Poa annua* points to fertilizing study. Golfdom 29(4):70, 72, 74, 76. Apr. 1955.
22. ———. *Poa annua* controls with arsenic materials. Golf Course Rptr. 23:5–8. Jan./Feb. 1955.
23. DAVIAUD, R., and Hascoet, M. Essais comparatifs de desherbage selectif avec le 2,4–D et le 2,4–D. action sur sanves et sur chardons. Cong. Internatl. de Phytopharm. (Compt. Rend.)3(2):715–717. 1952, pub. 1954.

24. DEFRANCE, J. A., and HART, S. W. Chemical control of mature, smooth crabgrass in lawns. Noeast. Weed Control Conf. Proc. 8:381–384. 1954.
25. ———, and ———. Crabgrass control with phenyl mercuric acetate on various strains of colonial bentgrass turf at two levels of fertility. Noeast. Weed Control Conf. Proc. 8:385–391. 1954.
26. ———, ———, and PALMATIER, E. A. Poison ivy (*Toxicodendron* radicans). R. I. Agr. Expt. Sta. Misc. P. 44, 8 p. July 1954.
27. DERSCHEID, L. A. Field bindweed (*Colvolvulus arvensis*). No. Cent. Weed Control Conf. Res. Rpt. 11:14–24. 1954.
28. DIEHL, R. Canadian thistle control. No. Cent. Weed Control Conf. Proc. 11:132. 1954.
29. DUNN, P. P. Wild oat control on my farm. No. Cent. Weed Control Conf. Proc. 11:131–132. 1954.
30. ENGEL, R. E., and ALDRICH, R. J. Control of annual bluegrass (*Poa annua*) in fairway-type turf. Noeast. Weed Control Conf. Proc. 9:353–355. 1955.
31. ———, and ———. Preliminary results of chemical control of goosegrass (*Eleusine indica*) in greens-type turf. Noeast. Weed Control Conf. Proc. 9:357–358. 1955.
32. ESTEVES-DE-SOUSA, A. Eradication of *Cyperus rotundus L.*, with 2,4–D. (In Portuguese) Portugaliae Acta Biol. Ser. A., 4:5–25. Ref. 1954.
33. FISCHER, G. W. Barberry (*Berberis*) control a cinch bet. Wash. Farmer 80:226. Mar. 17, 1955.
34. FITZGERALD, J. N. Control of grass in lucerne. New Zeal. J. Agr. 90:301, 303. Mar. 15, 1955.
35. FLETCHALL, O. H. Johnsongrass and Bermuda grass. No. Cent. Weed Control Conf. Res. Rpt. 11:10–11. 1954.
36. FRIESEN, H. A. Toadflax and other perennial herbaceous weeds. No. Cent. Weed Control Conf. Res. Rpt. 11:27–34. 1954.
37. FULTS, J. L. How can we control crabgrass (*Digitaria*) Colo. Farm & Home Res. 5(6):3–5. Mar./Apr. 1955.
38. GALLAGHER, J. E., and EMERSON, B. H. Crabgrass (*Digitaria*) control observations for 1954. Noeast. Weed Control Conf. Proc. 9:385–389. 1955.
39. GARICHKIN, A. I. Some agrotechnical measures for controlling *Paspalum digitaria*. (In Russian) Akad. Nauk Azerbaidzhansk. SSR. Inst. Zeml. Trudy 2:87–93. 1953.
40. GIBBENS, R. T. Control of Johnson grass on Cinclare properties. Amer. Soc. Sugar Cane Technol. Proc. 4:6–11. 1950–53, publ. Jan. 1955.
41. GILES SAEZ, J. Efecto del 2,4–D; TCA, CMU y ammate sobre la grama china, grama dulce, coquito y carretilla. Agronomia (Lima) 19(78):39–51. 1954?
42. GOETZE, N. Some factors affecting the chemical control of velvet grass, *Holcus lanatus* in sods of Astoria bentgrass, *Agrostis tenuis*. Agron. Abs. 47:74. 1955.
43. GONZALEZ LAGUINGE, E. Con herbicidas pueden combatirse los cardos. Chacra 25(295):91–92. June 1955.
44. GRANSTROM, B. Chemical control of Cirsium arvense Scop. Sweden, Lantbrhogsk. Ann. 21:281–285. 1954.
45. GT. BRIT. MINISTRY OF AGRICULTURE AND FISHERIES. The control of rushes (*Juncus*). Gt. Brit. Min. Agr. & Fisheries. Adv. L. 433, 5 p. Feb. 1955.
46. GT. BRIT. MINISTRY OF AGRICULTURE, FISHERIES AND FOOD. Ragwort (*Senecio jacobaea*). Gt. Brit. Min. Agr. & Fisheries. Adv. L. 280, amend. 4 p. June 1955.
47. GRIGSBY, B. H., REIMER, C. A., and CUTLER, W. A. Observations on the control of cattail, *Typha spp.* by chemical sprays. Mich. Agr. Expt. Sta. Q. B. 37:400–406. Feb. 1955.
48. HART, S. W., and DEFRANCE, J. A. The pre-emergence control of smooth crabgrass (*Digitaria ischaemum*) with chemicals in lawn turf. Noeast. Weed Control Conf. Proc. 9:345–351. 1955.

49. HAUSER, E. W., THOMPSON, J. T., and STACY, S. V. The effects of chemicals on the control of Johnson grass and nutgrass with and without disking. So. Weed Conf. Proc. 8:399–404. 1955.
50. HELGESON, E. A. Chemical control of wild oats. No. Cent. Weed Control Conf. Proc. 11:123–124. 1954.
51. HURD, R. M. Effect of 2,4–D on some herbaceous range plants. J. Range Mangt. 8:126–128. May 1955.
52. INDIA. CENTRAL TOBACCO RESEARCH INSTITUTE. Control of "orobanche". Indian Tobacco 5:33. Jan./Mar. 1955.
53. IVANOV, P. K., and KIREEV, V. N. Agrobiological principles of Canada thistle (*Cirsium arvense*) control on the irrigated lands of the Volga area. (In Russian) Agrobiologiia 6:3–9. Nov./Dec. 1954.
54. JAGSCHITZ, J. A., and CORNMAN, J. F. Duration of clover control with endothal and with 2,4,5–T in turf mowed at lawn and fairway height. Noeast. Weed Control Conf. Proc. 8:393–398. 1954.
55. ———, ———, and FERTIG, S. N. Selective clover control in putting green turf with endothal and 2,4,5–T formulations. Noeast. Weed Control Conf. Proc. 8:399–410. 1954.
56. JOHNSON, L. D. Control of Ulothrix zonata in circular ponds. Prog. Fish-Cult. 17:126–128. July 1955.
57. JONES, K. W. Further experiments on witchweed (*Striga hermontheca*) control. I. Sudan. Min. Agr. Res. Div. Mem. 46:331–339. 1954.
58. KADAMBI, K., and DABRAL, S. N. Preliminary note on the use of butyle ester in eradicating Lantana. Indian Forester 80:574–576. Sept. 1954.
59. KALAMKAR, R. J., and EKBOTE, R. B. Effect of C.M.U. and T.C.A. weedicides on kans (*Saccharum spontanium*). (Abs.) Indian Sci. Cong. Proc. 40(3):147. 1953, pub. 1954.
60. KING, L. J., and KRAMER, J. A. A review of the crabgrass (*Digitaria ischaemum* and *D. Sanguinalis*) with notes on their pre-emergence control in turf. Noeast. Weed Control Conf. Proc. 9:359–363. 1955.
61. KINNE, E., and FERTIG, S. N. Preliminary report on control of bedstraw in birdsfoot trefoil seedings. Noeast. Weed Control Conf. Proc. 8:355–361. 1954.
62. KNUTSSON, G. Wildoats and their control (In Swedish) Uppsala Lans Hushsallsk. Forsok och Undervis. 1954:76–80.
63. KONNIK, B., and SAFRA, R. Control of Ambrosia by the chemical method. (In Russian) Zemledelie 3(2):112–115. Feb. 1955.
64. KRALL, J. L. Chemicals and competitive crops for the control of leafy spurge (*Euphorbia esula*) in central Montana. Mont. Agr. Expt. Sta. B. 510, 15 p. May 1955.
65. LEE, O. C. Ways to control wild garlic. Hoard's Dairyman 100:230. Mar. 10, 1955.
66. ———, and OYER, E. B. Johnsongrass (*Sorghum halepense*) control. Purdue U. Ind. Agr. Ext. L. 369, 6 p.–folder. 1954.
67. LEE, W. O., and TIMMONS, F. L. Control of dodder (*Cuscuta*) in alfalfa seed crops with pre-emergence applications of CIPC. Agron. 47:77. 1955.
68. LEGGETT, H. W. Wild oats. Saskatchewan. U. Farm Weed Addresses & Proc. 1955:37–40.
69. LEONARD, O. A. Poison oak (*Toxicodendron quercifolium*) and its control Calif. U. Agr. Ext. L. 40, 6 p.–folder. Nov. 1954.
70. LEONARD, W. F. Control of Spanish heath. New Zeal. J. Agr. 90:48. Jan. 15, 1955.
71. LLOYD, C. H., and ELEY, G. W. Multiflora rose eradication. J. Soil & Water Conserv. 10:78–80. Mar. 1955.
72. LOUIS, MARIE, P. La linaire vulgaire dans le Quebec, Canada. Rev. d'Oka 29:29–32. Ref. Mar./Apr. 1955.
73. LUK'IANENKO, I. A. Method of controlling quackgrass (*Agropyron repens*). (In Russian) Zemledelie 3:126. Jan. 1955.
74. MACRAE, J. W. Ragweed (*Ambrosia artemisiifolia*) in Ontario. Canada. Natl. Weed Comt. East. Sect. Proc. 8:70–72. 1954, pub. 1955.
75. MARSHALL, R. P. Test with dormant oil fails to control crabgrass. Sci. Tree Topics 2:11. 1953.

76. McILVAIN, E. H. At last you can lick shinnery oak. (*Quercus havardii*)! Capper's Farmer 66(6):41, 69–70. June 1955.
77. McKELLAR, W. A. Hormone control of nodding thistle (*Carduus nutans*) New Zeal. J. Agr. 90:515–516. May 16, 1955.
78. McLEOD, J. H. Progress report on the biological control of goatweed (*Hypericum perforatum L.*) Brit. Columbia Agron. Assoc. Conf. Rpt. 1955:28.
79. MEADLY, G. R. W. Weeds of Western Australia; wild radish (*Raphanus raphanistrum L.*) West. Austral. Dept. Agr. J. (ser. 3) 4:161–162, 165–166, 169. Mar./Apr. 1955.
80. ———, and PEARCE, G. A. A further chemical trial with doublegee (*Emex Australis*). West. Austral. Dept. Agr. J. (ser. 3) 4:229–230,232,235. Mar./Apr. 1955.
81. MELANDER, L. W., LUNGREN, E. A., and WATSON, W. M. Killing native barberry with hormone-type herbicides. Weeds 3:123–130. Ref. Apr. 1954.
82. MITCHELL, W. H., and PHILLIPS, C. E. Chickweed control in pasture seedlings. Noeast. Weed Control Conf. Proc. 8:323–326. 1954.
83. MONDELLO, R. Observation on ragweed control in Montreal. Canada. Natl. Weed Comt. East. Sect. Proc. 8:72–74. 1954, pub. 1955.
84. MONTSERRAT, P. La Ambrosia tenuifolia Sprengel en Espana. Barcelona. Inst. Bot. Collect. Bot. 4:311–313. 1954.
85. MUNE, T. L., and PARHAM, J. W. Water hyacinth-bekabekairage (*Eichhornia crassipes*. Solms.) Fiji. Dept. Agr. J. 25:82. Dec. 1954.
86. ———, and ———. Weed control: mintweed—timoci ni vavalagi (*Hyptis pectinata* (L.) Poit.). Fiji. Dept. Agr. J. 25:80. Dec. 1954.
87. NAUDE, T. J. Biological control of jointed cactus (*Opuntia aurantiaca*). Farming So. Africa 30:259–260, 272. May 1955.
88. NORTHERN IRELAND. MINISTRY OF AGRICULTURE. The ragwort menace. North. Ireland. Min. Agr. Mon. Agr. Rpt. 30:72–74. July 1955.
89. ORTH, H. Zur bekampfung von *Allium vineale* im grunland. (Abs.) Angew. Chem. 67:311. June 7, 1955.
90. OWENS, C. B. Sodium trichloroacetate—centipede grass killer. So. Weed Conf. Proc. 8:226–228. 1955.
91. PAIXAO, J. DA C. Reaction of Emilia sonchifolia D. C. to various herbicides. 1. Action of sodium salts of 2,4–D, orthochlorophenoxyacetic acid, and T.C.A. 90%. (In Portuguese) Agronomia (Rio de Janeiro) 13:167–176. Apr./June 1954.
92. PALMER, E. J. Can we control Halogeton? Our Pub. Lands. 5:4–5,18–19, 22–23. Jan. 1955.
93. PERKINS, F. A. Prickly-pear control in Australia. Foreign Agr. 19:123–124. June 1955.
94. PETERSEN, H. I. Watch out for wild oats—it is high time! (In Danish) Dansk Landbr. 74:393–394. July 28, 1955.
95. PRICE, B. Jimson weed. Ohio Conserv. B. 19(6):20. June 1955.
96. RALEIGH, S. M. Chickweed control in alfalfa in Pennsylvania. Noeast Weed Control Conf. Proc. 8:329. 1954.
97. ———. Quackgrass control. Noeast. Weed Control Conf. Proc. 9:277–278. 1955.
98. RAUCHFUSS, F. Halogeton and good range management. Wyo. Range Mangt. 79, 2 p. Feb. 1955.
99. REA, H. E. How you can kill Johnson grass. Cotton Gin & Oil Mill Press 56(17):52, 56. Aug. 13, 1955.
100. ———. The effectiveness of Dalapon in controlling Johnson grass (*Sorghum halepense*). So. Weed Conf. Proc. 8:394–396. 1955.
101. ———, and NORRIS, M. J. Crown treatment of scattered Johnson grass (*Sorghum halepense*) infestations. So. Weed Conf. Proc. 8:397–398. 1955.
102. ———, and ———. Hexachloroacetone and related herbicides for controlling Johnson grass (*Sorghum halepense*). So. Weed Conf. Proc. 8:392–393. 1955.
103. REHM, S. Control of nut-grass (*Cyperus esculentus* and *C. rotundus*) in vegetable crops. Farming S. Africa 30:244–227. Ref. Apr. 1955.

104. ROACH, M. E. Cholla cacti (*Opuntia spinosior*) their spread and control. Ariz. Stockman 21(1):18–19, 24–25. Jan. 1955.
105. ROBINSON, R. G. Flax. No. Cent. Weed Control Conf. Res. Report 11:67–71. 1954.
106. ROE, R. C., and HARRIS, D. J. Green grow the rushes (*Juncus*) o! These pests of wet and heavy pastures can be eradicated by spraying and ploughing. Farmer & Stock-Breeder 69(3418):57, 59. Apr. 26/27, 1955.
107. SAND, P. F. Hoary cress, Russian knapweed and bur ragweed. No. Cent. Weed Control Conf. Res. Rpt. 11:25–26. 1954.
108. SANTELMANN, P. W., and WILLARD, C. J. Dalapon for quackgrass control. Agron. Abs. 46:96. 1954.
109. ———, and ———. Dalapon for quackgrass control. No. Cent. Weed Control Conf. Proc. 11:63–64. 1954.
110. SEXSMITH, J. J. Response of Russian thistle to 2,4–D and additive nutrient elements. No. Cent. Weed Control Conf. Proc. 11:8–10. 1954.
111. SMIRNOV, B. M., and MAMONOV, N. N. Control of spurge (*Euphorbia*) and European bindweed (*Convolvulus arvensis*) under conditions of irrigation. (In Russian) Zemledelie 2(9):58–61. Sept. 1954.
112. SMITH, A. Like a lavender octopus. New Zeal. Dairy Exporter 30(8): 26,28–29. Feb. 1955.
113. SMITH, J. M. Biological control of common St. John's wort (*Hypericum perforatum*) in British Columbia in 1954. Canada. Natl. Weed Comt. East Sect. Proc. 8:84–88. 1954, pub. 1955.
114. STOA, T. E., CLAGETT, C. O., SWALLERS, C. M., KLOSTERMAN, H. J. and KINGSLEY, A. F. Foxtail—how does it affect yields and nutritional needs of flax? N. Dak. Agr. Expt. Sta. Bimon. B. 17:163–166. May/June 1955.
115. STURIALE, F. Le orobanche (*Orobanche*). Osserv. Region di Fitopatol. per la Calabria. C. 15, 4 p. Feb. 1955.
116. TAYLOR, C. R. Control of water hyacinth (*Eichhornia*) in Rotorua district. New Zeal. J. Agr. 90: 188–189, 191, 193, 195. Feb. 15, 1955.
117. THORNTON, M. K. Killing nut grass or coco (*Cyperus rotundus*). Tex. Agr. Col. Ext. L-188, 2 p. 1954?
118. TIMMONS, F. L., and LEE, W. O. Control of dodder (*Cuscuta*) in alfalfa seed crops by stubble treatments applied following removal of the first hay crop. Agron. Abs. 47:79. 1955.
119. TINGEY, D. C., and COOK, C. W. Eradication of mule ear with herbicides. Utah Agr. Expt. Sta. B. 375, 16 p. May 1955.
120. TOOHEY, C. L. Control of para grass in a mill drain. Queensland Bur. Sugar Expt. Sta. Cane Growers' Q. B. 18:131. Apr. 1, 1955.
121. URQUHART, R. J. Scotsmen spend £73,000,000. Brit. Agr. B. 8(37):8–12. May 1955.
122. VENGRIS, J. Quackgrass (*Agropyron repens*) control in field corn by preplanting applications of maleic hydrazide and Dalapon. Noeast. Weed Control Conf. Proc. 9:399–400. 1955.
123. VINE, R. Gorse (*Ulex*) spraying by helicopter. New Zeal. Farmer 76(2):3. Mar. 24, 1955.
124. VLADIMIROV, I. F. Agrotechnical method of controlling water pepper (*Acroptilon* picres) on its northern range limit. (In Russian) Moscow. Glav. Bot. Sad. B. 19:119–125. 1954.
125. WESTMORELAND, W. G., and KLINGMAN, G. C. Bermuda grass (*Cynodon dactylon*) control. N.C. State Agr. Col. Ext. Folder 114, 6 p. Mar. 1955.
126. WIANCKO, M. R. Couch grass control. Canada. Natl. Weed Comt. East. Sect. Proc. 8:116–119. 1954, pub. 1955.
127. WIESE, A. F., and REA, H. E. Bindweed (*Convolvulus arvensis*) control in the Panhandle of Texas. Tex. Agr. Expt. Sta. B. 802, 8 p. Apr. 1955.
128. ———, and ———. Chemical and cultural control of field bindweed on the High Plains of Texas. No. Cent. Weed Control Conf. Proc. 11:64–65. 1954.
129. WILLARD, C. J. Canada thistle (*Cirsium arvense*). No. Cent. Weed Control Conf. Res. Rpt. 11:12–13. 1954.
130. WINN, D. B. Gorse (*Ulex europaeus, L.*). So Austral. Dept. Agr. J. 58:400, 412. May 1955.

131. ————. Weeds of South Australia; gorse (*Ulex europaeus, L.*). So. Austral. Dept. Agr. J. 58:400, 412. May 1955.
132. WOMERSLEY, J. S. A foetid weed from Rabaul (*Paederia foetida*). Papua & New Guinea Agr. J. 9:92. Oct. 1954.
133. WOOD, H. E. Wild oat (*Avena fatua*) control. No. Cent. Weed Control Conf. Proc. 11:122–123. 1954.
134. YEO, R. R. Chemical control of bindweed (*Convolvulus arvensis*). N. Mex. Agr. Expt. Sta. Press B. 1126, 6 p. folder. Aug. 1954.

Biological

1. CONTROL of weeds by plant-eating insects. Rur. Res. C.S.I.R.O. 11:10–15. Mar. 1955.
2. DISCUSSION ON THE BIOLOGICAL CONTROL OF WEEDS. Commonwealth Ent. Conf. Rpt. 6:95–101. Dec. 1954.
3. FULLER, J. C. Four-legged weed cutter. S. C. Wildlife 2(2):5, 23. Spring 1955.
4. HUTCHINS, R. E. Dodder—a vampire plant. Nat. Hist. 65, i.e. 64:378–381. Sept. 1955.
5. PAGE, W. R. Sheep pick wild oats from flax crop. No. Cent. Weed Control Conf. Proc. 11:134. 1954.
6. WILLIAMS, J. R. The biological control of weeds. Commonwealth Ent. Conf. Rpt. 6:95–98. Dec. 1954.

IV. CHEMICAL AND BIOCHEMICAL INVESTIGATIONS

1. ABERG, B., and JONSSON, E. Studies on plant growth regulators. XI. Experiments with pea roots, including some observations on the destruction of indoleacetic acid by different types of roots. Sweden. Lantbrhosk. Ann. 21:401–416. Ref. 1954.
2. AHMAD, G.—UD-D., and HAMID, A. Studies in selective weed control in the Punjab. Pakistan J. Sci. 6:209–217. Oct. 1954.
3. ARCENEAUX, C. J. Microscopic fusion study of 2,4,5–trichlorophenoxyacetic acid and related compounds. Analyt. Chem. 27:979–983. June 1955.
4. ARRIGONI, O., and MARRE, E. Inhibiting action of indoleacetic and naphthaleneacetic acid on enzymatic oxidation of ascorbic acid in pea ("Pisum sativum") extracts. (In Italian) Accad. Naz. dei Lincie. Cl. di Sci. Fis. Mat. e Nat. Atti. Rend. (ser.8) 17:390–394. Dec. 1954.
5. BOURIQUET, R. Action de diverses substances synthetiques sur le developpement des tissus vegetaux cultives in vitro. Ann. Biol. 58:371–383. Ref. July/Oct. 1954.
6. CURRIER, H. B., and PEOPLES, S. A. Phytotoxicity of hydrocarbons. Hilgardia 23:155–173. Ref. Nov. 1954.
7. DALLYN, S. The effect of soil organic matter levels on several herbicides. Noeast. Weed Control Conf. Proc. 8:13–20. 1954.
8. ERICKSON, L. C. 2,4–D residue on lemons. Citrus Leaves 35(4):13. Apr. 1955.
9. ————. 2,4–D retention. Calif. Weed Conf. Proc. 7:51–54. 1955.
10. GOLDACRE, P. L. The photochemical inactivation of indoleacetic acid sensitized by non-protein components of plant tissues. Austral. J. Biol. Sci. 7:225–250. Ref. Aug. 1954.
11. HENDERSON, J. H. M., and DEESE, D. C. Correlation between endogenous auxin and its destruction in vivo by 2:4–dichlorophenoxyacetic acid in plants. Nature (London) 174:967–968. Nov. 20, 1954.
12. HILST, A. R. The effect of 2,4–D on quality and agronomic characteristics of wheat. Diss. Abs. 15:663–664. May 1955.
13. ISLEIB, D. R. Phytotoxicity of 2,4–dichlorophenoxyethyl sulfate and its derivatives. (Abs.) Iowa State Col. J. Sci. 29:439–440. Feb. 15, 1955.
14. KNIPLING, E. F. Resistance to herbicides and insecticides; introductory remarks. In Sevag, M. G., ed. Origins of resistance to toxic agents, p. 97–98. New York, Acad. Press, 1955.
15. LEAPER, J. M. F., BISHOP, J. R., and ANDERSON, W. P. Relative biological activities of the four monochloro ortho cresoxy acetic acids. Noeast. Weed Control Conf. Proc. 9:9–14. 1955.

16. LEASURE, J. K. Some residual effects of herbicide materials. So. Weed Conf. Proc. 8:322–325. 1955.
17. LIVINGSTON, C., PAYNE, M. G., and FULTS, J. L. Effects of maleic hydrazide and 2,4–dichlorophenoxyacetic acid on the free amino acids in sugar beets. Bot. Gaz. 116–148–156. Ref. Dec. 1954.
18. LOCKHART, J. A. The role of 2,4–dichlorophenol in the destruction of indoleacetic acid by peroxidase. Plant Physiol. 30:86–88. Ref. Jan. 1955.
19. NANCE, J. F. Effects of indoleacetic acid on the syntheses of pectic substances. (Abs.) Plant Physiol. 30(sup.):xii–xiii. 1955.
20. PLATT, R. S. The inactivation of auxin in normal and tumorous tissues. Ann. Biol. 58:349–359. July/Oct. 1954.
21. POIGNANT, P. Recherches sur la relation entre la structure chimique et l'activite phytocide de differents sels, esters et autres derives de l'acide monochloracetique. Acad. des Sci. Compt. Rend. 239:1408–1410. Nov. 22, 1954.
22. RALEIGH, S. M. New chemicals promise quack grass (*Agropyron repens*) control in corn. Sci Farmer (Pa. Sta.) 2(4):9. Spring 1955.
23. RENNEY, A. J. Mode of action of some common herbicides other than 2,4–D. (Sum.) Brit. Colombia Agron. Assoc. Conf. Rpt. 1955:33–34.
24. SAMANTARAI, B., and MOHANTY, D. N. Changes in titratable acidity in isolated leaves during the period of root emergence following hormone treatment. Indian Sci. Cong. Assoc. Proc. 42(3,abs.):258. 1955.
25. SEVAG, M. G., REED, R. D., and REYNOLDS, O. E., ed. Origins of resistance to toxic agents. Proceedings of the Symposium held in Washington, D. C., March 25–27, 1954. New York, Acad. Press, 1955. 471 p.
26. SWITZER, C. M. Effects of herbicides on mitochondrial enzyme systems. No. Cent. Weed Control Conf. Proc. 11:10–12. 1954.
27. TSITOVICH, I. K. In regard to biochemical verification of the selective action of 2,4–D on dicotyledonous plants and grasses. (In Russian) Akad. Nauk SSSR. Dok. 100:587–590. Ref. Jan. 21, 1955.
28. VIRTANEN, A. I., and KARI, S. 4–hydroxypiperidine–2–carboxylic acid in green plants. Acta Chem. Scand. 9:170–171. 1955.
29. VOIGHT, G. K. The effect of applied fungicides, herbicides, and insecticides on the content of nutrient elements in coniferous seedlings. Agron. Abs. 46:55. 1954.
30. ————. The effect of applied fungicides, herbicides and insecticides on the content of nutrient elements in tissue of coniferous seedlings. Soil Sci. Soc. Amer. Proc. 19:237–239. Apr. 1955.
31. ————. The effect of fungicides, herbicides, and insecticides on the accumulation of phosphorus by Pinus radiata as determined by the use of p^{32}. Agron. J. 46:511–513. Nov. 1954.
32. WAIN, R. L. Selective herbicides: a new principle of weed control. Agr. Rev. 1:25–31. June 1955.

V. SPECIAL CHARACTERISTICS OF WEEDS

1. WILSON, C. L., and DEAMING, J. M. Laboratory and greenhouse evaluations of some new herbicides for grassy weeds, including certain a-chloroacetamides and chlorallyl dithiocarbamates. Agron. Abs. 47:80. 1955.

Poisonous Plants and Their Control

1. BARNES, B. Poisonous plants in Britain. Discovery 16:343–345. Aug. 1955.
2. BELLUE, M. Stock poisoning plants. Calif. Weed Conf. Proc. 7:26–29. 1955.
3. CASEY, J. Better watch these plants. Amer. Forests 61(7):19,41. July 1955.
4. FLETCHER, W. W., and MARTIN, D. J. Poisonous plants in south-west Scotland. West Scot. Agr. Col. Adv. L. 43, 4 p. Apr. 1955.
5. GARDNER, C. A., and BENNETTS, H. W. Poison plants of Western Australia; cabbage poison (*Velleia discophora F. Muell.*) West Austral. Dept. Agr. J. (ser.3) 4:193–194. Mar./Apr. 1955.
6. ————, and ————. Poison plants of Western Australia: ironwood, *Erythrophlocum chlorostachys* (F. Muell.). West. Austral. Dept. Agr. J. (ser.3)3:395–397. July/Aug. 1954.

7. HANSON, M. Watch out for poisonous plants. Canad. Cattlemen 18(6):14–15,33–37, June 1955.
8. JONES, N. R. Economic losses due to poison oak dermatosis. Calif. Weed Conf. Proc. 7:3–6. 1955.
9. KILGUS, J. F. Poison ivy dermatitis control procedures. Noeast. Weed Control Conf. Proc. 8:533–537. 1954.
10. KROCHMAL, A., and LAVRENTIADES, G. Poisonous plants of Greece. Econ. Bot. 9:175–189. Apr./June 1955.
11. MITCHELL, J., and MITCHELL, F. N. Jimson weed (*Datura stramonium*) poisoning in childhood. J. Ped. 47:227–230. Aug. 1955.
12. MONTGOMERY, F. H., HENDERSON, J. A., and BIBBEY, R. O. Plants poisonous to livestock in Ontario. Ontario. Dept. Agr. B. 508, 39 p. May 1955.
13. MUENSCHER, W. C., and WINNE, W. T. Common poisonous plants. N. Y. State Col. Agr. Ext. Cornell Ext. B. 538, 31 p. Jan. 1955.
14. NORRIS, J. J., and VALENTINE, K. A. Principal livestock-poisoning plants of New Mexico ranges. N. Mex. Agr. Expt. Sta. B. 390, 78 p. Ref. Sept. 1954.
15. OGILVIE, S. Chokecherry toxic to an antelope. J. Mammal. 36:146. Feb. 1955.
16. PEOPLES, S. A. Toxicology of poisonous plants. Calif. Weed Conf. Proc. 7:29–31. 1955.
17. RATERA, E. L. Algunas solanaceas de la flora argentina toxicas para el ganado. Res. 23:29908. Feb. 20, 1955.
18. REGAL, V. Poisonous plants in pastures. (In Czech.) Za Socialist. Zemedel 5:542–545. May 1955.
19. SPERRY, O. E., DOLLAHITE, J. W., MORROW, J., and HOFFMAN, G. O. Texas range plants poisonous to livestock. Tex. Agr. Expt. Sta. B. 796, 47 p.
20. STUCKEY, I. H. Animals don't usually eat poison plants. R.I. Agr. 1(4): 5–6. Summer 1955.
21. TIWARI, N. M. Akav: a digitalis like cattle poison. (Abs.) Indian Sci. Cong. Proc. 40(3):64. 1953, pub. 1954.

Pathological and Entomological Relationships

1. MARTIN, H. Some basic problems in the application of chemistry to crop protection. Ann. Appl. Biol. 42:275–281. Ref. Feb. 1955.

VI. NATURE & PROPERTIES CHEMS. USED AS HERBS

1. ABERG, E. Different isomers of phenoxyacetic acids and phenols—their effect and value as weed killers. Sweden Lantbrhogsk. Ann. 21:213–260. 1954.
2. ALDRICH, R. J. Promising new chemicals. Noeast. Weed Control Conf. Proc. 9:7. 1955.
3. ANDERSON, E. G. A summary of weed control investigations in eastern Canada. Canada. Natl. Weed Comt. East. Sect. Proc. 8:24–35. 1954. pub. 1955.
4. ANDERSON, W. P., Jack, C. C., VANGELUWE, J. D., and MARSHALL, E. R. The effect of a high and a low volatile ester of 2,4–D on seven varieties of field corn as determined by injury and yield. Noeast. Weed Control Conf. Proc. 8:289–292. 1954.
5. BAKER, J. B., STEMPER, E. R., and THOMAS, C. H. Comparative efficiency of new chemicals as herbicides. So. Weed Conf. Proc. 8:201–202. 1955.
6. BEATTY, R. H. Amino triazole. Calif. Weed Conf. Proc. 7:43–47. 1955.
7. BENNETT, J. M. Comparison of six herbicides for dormant basal brush control. Canada Natl. Weed Comt. East. Sect. Proc. 8:50–53. 1954, pub. 1955.
8. BERRIE, G. M., and NISBET, A. F. R. Hormone weedkillers. West Scot. Agr. Col. Adv. L. 32, 8 p. 1954.
9. BIVINS, J., and KOFRANEK, A. M. New weed killer, vapam, effective in experiments. South. Florist & Nurseryman 68(2):81, 89–90. Mar. 25, 1955.
10. BROWN, J. W., and THRONE, J. A. Species sensitivity to chemicals tested for herbicidal properties. Weeds 3:171–176. Apr. 1954.

11. BURGOYNE, D. L. What's new in weed control. Calif. Weed Conf. Proc. 7:31–33. 1955.
12. CARLSON, R. F. Preliminary tests with CMU for weed control in established vineyards. Noeast. Weed Control Conf. Proc. 9:209–120. 1955.
13. CHANISHVILI, SH. F. Results of scientific-research work in studying chemical methods of weed control. (In Georgian) Akad. Nauk Gruzinskoi SSR. Inst. Polevod. Trudy 8:75–98. Ref. 1954.
14. CHEVELEY, S. Selective weed-killers. Fert. & Feed. Stuffs J. 42:305–306. Mar. 30, 1955.
15. CIFERRI, R. Susceptibility of the most important weeds to some selective chemical herbicides. (In Italian) Not. sulle Mal delle Piante 29:30–42. 1955.
16. COMMISSION INTERNATIONALE DES INDUSTRIES AGRICOLES. Bibliographie sur l'herbicide 2,4–D et la preparation de l'acide 2,4–dichlorophenoxy-acetique et de ses esters. Comn. Internatl. des Indus. Agr. Bibliog. 2651, 28 p. Feb. 8, 1955.
17. COULTER, L. L., and GIBSON, J. W. A progress report on field experiences with silvex. No. Cent. Weed Control Conf. Proc. 11:90–91. 1954.
18. CRAFTS, A. S. General-contact weed killers. Calif. Agr. Expt. Sta. C. 447, 16 p. May 1955.
19. ————, and HARVEY, W. A. Weed control by soil sterilization. Calif. Agr. Expt. Sta. C. 446, 20 p. Apr. 1955.
20. DALLYN, S. L., SAWYER, R. L., SEIF, R. D. and HALIBURTON, T. H. Effects of soil organic matter on herbicides used in vegetable production. Noeast. Weed Control Conf. Proc. 9:87. 1955.
21. DITTMER, H. J. Some observations on the effect of 2,4–D on sixty woody plants. Agron. J. 46:581. Dec. 1954.
22. DOLAN, D. D. Factors determining the effectiveness of pre-emergence herbicidal treatments. Noeast. Weed Control Conf. Proc. 8:77–82. 1954.
23. DUNKEL', E. E., and EGLITE, A. K. Experiments in applying maleic hydrazide as a herbicide. (In Russian) Latv. PSR Zinatnu Akad. Vest. 11:57–62. Ref. 1954.
24. DUPEE, L. F., and GARDNER, K. The analysis of monochloracetic acid; a partition chromatographic method. Analyt. Chim. Acta 13:57–63. Ref. July 1955.
25. ELWELL, H. M. Interim report on urea herbicides for brush control in Oklahoma. No. Cent. Weed Control Conf. Proc. 11:113–115. 1954.
26. ENGEL, R. W., PRICE, N. O., LINKOUS, W. N., and BELL, W. B. A colorimetric method for the detection of highly chlorinated naphthalenes. Va. Agr. Expt. Sta. Tech. B. 121, 7 p. Aug. 1954.
27. ERICKSON, L. C. A total evaluation of eleven selective herbicides. Agron. Abs. 46:94. 1954.
28. EVANS, S. A. New chemicals for selective weed control. Brit. Agr. Contract. Assoc. Members' B. 3(29):8–9. May 1955.
29. FARLEY, J. L. Use of sodium arsenite for controlling aquatic plant growths. Pub. Works 86(7):73. July 1955.
30. FOLKNER, J. S. Responses of ryegrass and Bermuda grass to maleic hydrazide. (M.H. 30): Agron. Abs. 47:73–74. 1955.
31. FOY, C. L. Effectiveness of isopropyl N-(3–chlorophenyl) carbamate as a selective pre-emergence herbicide in cotton. Weeds 3:282–291. Ref. July 1954.
32. ————, and MILLER, J. H. The response of cotton to directed sprays of Dalapon. So. Weed Conf. Proc. 8:87–91. 1955.
33. FRIESEN, H. A. The effect of various formulations of MCP and 2,4–D on weeds in grain crops. No. Cent. Weed Control Conf. Proc. 11:46–51. 1954.
34. FURTICK, W. R. Preliminary results of the herbicidal activity of two new chemical groups: chloro acetamides (CEAA & CDEA) and dithio carbamates (CDEC & CDEA). Agron. Abs. 47:77. 1955.
35. GALLATIN, M. H., and NOONAN, J. C. Preliminary observations in the use of herbicides in South Dade County. So. Weed Conf. Proc. 8:364–367. 1955.

36. GARCIA CABEZON, A. El herbicida 2,4-D. Agricultura (Madrid) 24(273): 8–15. Jan. 1955.
37. GIBSON, J. W. Silvex—a new herbicide for brush control in the South. So. Weed Conf. Proc. 8:255–259. Ref. 1955.
38. GLEASON, L. S. Action of herbicides on woody plants. (Abs.) Iowa State Col. J. Sci. 29:415. Feb. 15, 1955.
39. GREULACH, V. A. Recent work on maleic hydrazide as a plant growth inhibitor. (Abs.) Elisha Mitchell Sci. Soc. J. 70:134–135. Dec. 1954.
40. HALL, W. C. Growth inhibition by amino triazole. (Abs.) Assoc. South Agr. Workers Proc. 52:155. 1955.
41. HAMM, P. C., and SPEZIALE, A. J. The correlation of structure and activity for a new class of herbicidal chemicals. No. Cent. Weed Control Conf. Proc. 11:16–18. 1954.
42. HANNAH, L. H. Field studies with a new class of herbicidal chemicals. No. Cent. Weed Control Conf. Proc. 11:73–75. 1954.
43. ———. Field studies with a new class of herbicidal chemicals. Noeast. Weed Control Conf. Proc. 9:15–19. 1955.
44. ———. Field studies with two new classes of herbicidal chemicals. So. Weed Conf. Proc. 8:316–321. 1955.
45. HANSEN, J. R., and OGLE, R. E. Response of eighteen plant species to DPA (3,4-D), 2,4-D, and MCP. Noeast. Weed Control Conf. Proc. 8:29–31. 1954.
46. HENRIET, J. Chimie et formulations des herbicides phenoxyacetiques. Rev. de l'Agr. 8:138–143. Feb. 1955.
47. ———. LES possibilites de melange des herbicides et autres produits chimiques agricoles. Rev. de l'Agr. 8:144–156. Ref. Feb. 1955.
48. HUISMAN, H. O., and SMIT, A. A new synthesis of 2,4–5-trichlorophenoxy-acetic acid (2,4,5-T). Rec. des Trav. Chim. des Pays-Bas 74:155–160. Feb. 1955.
49. JENSEN, A. O. 3-amino-1,2,4-triazole in California. Calif. Weed Conf. Proc. 7:47–48. 1955.
50. JOHNSON, E. Volatility studies of 2,4-D. Calif. Weed Conf. Proc. 7:54–57. 1955.
51. KATES, A. H., SPRAGUE, M. A., and ALDRICH, R. J. Promising chemicals for seedbed preparation. Down Earth 10(4):10–11. Spring 1955.
52. KESTER, G. H. New weapons in the war on weeds. Du Pont Mag. 49(2): 2–4. Apr./May 1955.
53. KLINGMAN, D. L. Promising weed killers being tested. Hoard's Dairyman 100:596–597,606. June 25, 1955.
54. ———. Promising chemicals being tested. No. Cent. Weed Control Conf. Proc. 11:128–131. 1954.
55. LINDER, P. J., SHAW, W. C., and MARTH, P. C. A comparison of the relative vapor activity and the relative rates of evaporation of several carbamates. So. Weed Conf. Proc. 8:306–308. 1955.
56. ———, ———, and ———. The relative vapor activity of several carbamates. (Abs.) Noeast. Weed Control Conf. Proc. 8:11–13. 1954.
57. MCCALL, G. L. Comparative use efficiency of the substituted urea herbicides for industrial weed control. Noeast. Weed Control Conf. Proc. 9:451. 1955.
58. MAGUIRE, M. H., and SHAW, G. Synthetic plant hormones. III. Aryl-oxymethyl-phosphonates. Chem. Soc. J., June 1955:1756–1760.
59. MARSHALL, E. R. Review of recent advances in chemicals and practices in weed control among various crops. Noeast. Weed Control Conf. Proc. 9:75–83. 1955.
60. MAXWELL, K. E. Two new classes of herbicidal chemicals. Calif. Weed Conf. Proc. 7:48–51. 1955.
61. MEYERS, W. A., ALLEN, W. W., and BEATTY, R. H. A comparison of field tests of standard and new brush killer formulations. Noeast. Weed Control Conf. Proc. 9:433–438. 1955.
62. ———, ———, and ———. A comparison of field tests of standard and new brush killer formulations. So. Weed Conf. Proc. 8:244–248. 1955.

63. MICHIELS, A., and DUSTIN, A. Le C.M.U. un nouvel herbicide plein de promesse. Parasitica 11:29–57. 1955.
64. MILLER, D. M. The polarography of maleic hydrazide. (Abs.) Chem. Canada 7(5):53. May 1955.
65. MILLER, L. P. Growth regulants, their nature and action. In Blanck, F. C., ed. Handbook of food and agriculture, p. 193–213. Ref. New York, Reinhold, 1955.
66. MULLISON, W. R. Vapor effects of 2,4–D and 2,4–T esters. N.P., 1953. 7 p.
67. NEUFELD, C. H. H., KREWSON, C. F., DRAKE, T. F., FONTAINE, T. D., MITCHELL, J. W., and PRESTON, W. H. Preparation and evaluation of substituted phenoxyacetyl derivatives of amino acids (abs.) Noeast. Weed Control Conf. Proc. 8:3. 1954.
68. NEX, R. W., and SWEZEY, A. W. Some chemical and physical properties of weed killers. Weeds 3:241–253. July 1954.
69. OLSEN, H. K. The chemical war against weeds. (In Danish) Landbonyt 9:187–190. Apr. 15, 1955.
70. PAGE, T. J. "Double trouble" for weeds. Dow Diamond 18(2):16–18. June 1955.
71. PASS, H. A., and WATT, B. J. Chemicals for farm use. Farm Equip. Dealer 11:23–26, 29, 63. Jan. 1955.
72. PEARSE, F. S. Progress report on Dalapon, Duron & Premerge. Canada. Natl. Weed Comt. East. Sect. Proc. 8:42–43. 1954, pub. 1955.
73. PETERSEN, H. I. Chemical weedkillers. (In Danish) Tolvmandsbladet 27:65–67. Mar. 1955.
74. ———. Experiences with the effect of chemical weedkillers in 1954. (In Danish) Dansk Landbr. 74:48–50. Jan. 27, 1955.
75. PHILLIPS, W. M. The effect of 2,4–D and MCP on sorghum. Agron. Abs. 46:96. 1954.
76. POPE, P. M., and WOODCOCK, D. Synthesis of plant-growth regulators. IV. Substituted –2–naphthyloxypropionic acids. Chem. Soc. J., Feb. 1955: 577–579.
77. PORTER, W. K., THOMAS, C. H., and STAMPER, E. R. An evaluation of combinations of chemicals as pre- and post-emergence herbicides. So. Weed Conf. Proc. 8:65–71. 1955.
78. RAMIREZ S., A. Los herbicidas hormonales o "matamalezas." Agrario 19(447):7–8, 10, 12. 1954.
79. READY, D., and MINARIK, C. E. New growth regulating compounds. IV. Selected toloxyacetic acids. Weeds 3:279–281. July 1954.
80. RIES, S. K., and JACOB, W. C. Design and analysis in chemical weed control research. Weeds 3:152–159. Ref. Apr. 1954.
81. ROAN, C. C. Insecticides, fungicides and herbicides. *In* Blanck, F. C. ed. Handbook of food and agriculture, p. 145–191. Ref. New York, Reinhold, 1955.
82. SABUROVA, P. V. On the nature of selective action of mineral oils as herbicides. (In Russian) Leningrad. Vsesoiuzn. Inst. Zashch. Rast. Trudy 5:164–170. 1954.
83. SCHOLL, A. W., and CARTWRIGHT, D. R. Bibliography of synthetic plant-growth substances. Huntington, W. Va. 1955.
84. SCHRIEBER, M. M. An evaluation of herbicidal materials and their effects on the yield and botanical composition of forage legumes with special reference to the control of yellow rocket. (*Barbarea vulgaris*). Diss. Abs. 15:8–9. Jan. 1955.
85. ———, and FERTIG, S. N. The effects of various herbicides on the yield and botanical composition of legumes. Noeast. Weed Control Conf. Proc. 8:363–375. 1954.
86. SCHWANZ, H. L. New way to kill tough weeds. Better Farming 125(4): 54–55. Apr. 1955.
87. SKOGLEY, C. R., and AHLGREN, G. H. Preliminary report on the use of several new arsenicals. Noeast. Weed Control Conf. Proc. 9:401–405. 1955.
88. SMITH, L. H. Precautions in the use of weed chemicals. No. Cent. Weed Control Conf. Proc. 11:127–128. 1954.

89. SOUTHWICK, L. Progress report on agricultural uses of Dalapon. Noeast. Weed Control Conf. Proc. 8:251–256. 1954.
90. STAALDUINE, D. VAN. Possibilities for controlling weeds before the sprouting of the plant. (In Dutch) Groenten en Fruit 10:867. Mar. 10, 1955.
91. STEFANYE, D., and Howard, W. L. Benzofuran derivatives related to 2,4–dichlorophenoxyacetic acid. J. Org. Chem. 20:813–818. July 1955.
92. SUGGITT, J. W. Herbicide specifications and laboratory evaluation procedures. Noeast. Weed Control Conf. Proc. 9:453–458. Ref. 1955.
93. ————. Procedures for laboratory evaluation of ester herbicides. Hydro Res. News 7:19–23. Jan./Mar. 1955.
94. SWEZEY, A. W. Dalapon in California. Calif. Weed Conf. Proc. 7:34–38. 1955.
95. TAFURO, A. J., and BEATTY, R. H. Progress report with greenhouse tests on Johnson grass (*Sorghum halepense*) seedlings using Amizol (3–amino–1, 2,4–triazole) as an addative with other herbicides. So. Weed Conf. Proc. 8:386–391. 1955.
96. THORNTON, M. K., and WATKINS, G. M. Dangers in using hormone-type weed and brush killers. Tex. Agr. Col. Ext. L-210, 4 p. Ref. 1954?
97. TILEMANS, E. M. Developpements recents des herbicides. Rev. de l'Agr. 8:119–137. Ref. Feb. 1955.
98. TOMIZAWA, C., and KOIKE, H. Studies on herbicides. (In Japanese) Natl. Inst. Agr. Sci. B. Ser. C. (Plant Path. & Ent. 4:25–73. Ref. Mar. 1954.
99. TUKEY, L. D. Maleic hydrazide—new plant growth regulator. Rur. New-Yorker 105:418, 422. July 2, 1955.
100. U. S. DEPT. OF AGRICULTURE. More and better weed killers for you. Better Farming 125(5):44. May 1955.
101. WAIN, R. L. A new approach to selective weed control. Ann. Appl. Biol. 42:151–157. Ref. Feb. 1955.
102. WARREN, G. F. Watch these new weed killers! Co. Agent & Vo-Ag Teacher 11(2):19–20. Feb. 1955.
103. WARREN, J. C. R. Maleic hydrazide. Canada Natl. Weed Comt. East. Sect. Proc. 8:44–45. 1954, pub. 1955.
104. WEBBER, E. R. Maleic hydrazide in agriculture. Agr. Merchant 34:421. Nov. 1954.
105. WINFIELD, J. D. Progress report on new studies with chlorate weed killers. Canada. Natl. Weed Comt. East. Sect. Proc. 8:36–37. 1954, pub. 1955.
106. WOODFORD, E. K. In the search for selective weed-killers. Chem. & Drug. 163:171–174. Feb. 12, 1955.
107. WOODS, F. W. Tests of two soil sterilants for forestry use. So. Weed Conf. Proc. 8:249–254. 1955.

VII. EFFECT HERBS ON SOILS, LIVESTK, & HUMANS

1. BOHMONT, D. W., and Slater, I. W. Weed flavors in milk destroy quality. Wyo. Agr. Col. Ext. C. 135, 8 p. 1954.
2. BYLTERUD, A. Dangers from using hormone preparations. (In Norwegian) Gartneryrket 45:435–437. June 17, 1955.
3. CARLOTTO, F. Incidence of poisoning from hydrocyanic acid in cattle. Destination of the meat. (In Italian) Vet. Ital. 5:959–961. Oct. 1954.
4. CHAMBIONNAT, A. Sequestrants et phytohormones; etude theorique et pratique des conditions d'utilisation des sequestrants dans les pulverisations des sels mineraux ou organiques de 2,4.D. Terre Marocaine 29:182–189. (Cont.) May 1955.
5. DAVIS, F. L., and SELMAN, F. L. Effects of water upon the movement of dinitro weed killers in soils. Weeds 3:11–20. Jan. 1954.
6. DUTTON, W. C. New herbicides. No. Cent. Weed Control Conf. Res. Rpt. 11:140–149. 1954.
7. HILL, G. D., MCGAHEN, J. W., BAKER, H. M., FINNERTY, D. W., and BINGEMAN, C. W. The fate of substituted urea herbicides in agricultural soils. Agron. J. 47: Feb. 1955.
8. ————, and ————. Further studies on soil relationships of the substituted urea herbicides for pre-emergence weed control. So. Weed Conf. Proc. 8:284–293. 1955.

9. MARTIN, A. C. Marsh and aquatic weed problems in wildlife habitat. Weeds 3:139–142. Apr. 1954.
10. OGLE, R. E., and WARREN, G. F. Fate and activity of herbicides in soils. Weeds 3:257–273. Ref. July 1954.
11. SHEETS, T. J. Residual activity of four substituted urea herbicides in soils. Agron. Abs. 47:79. 1955.
12. TAKIJIMA, Y., and HAYASHI, T. Studies on the behavior of 2,4–D in soils. 1–5. (In Japanese) J. Sci. Soil & Manure, Japan 25:49–52, 97–101. Ref. Aug.–Oct. 1954.
13. WESTLAKE, D. W. S. Effect of some agricultural chemicals on soil microorganisms. (Abs.) Brit. Columbia Agron. Assoc. Conf. Rpt. 1955:17.

VIII. EQUIP., METHODS APPL., & HERB. CALC.

1. ABBISS, H. W. Fair play for the flame gun. Mech. Hort. 2:39–40. Autumn 1954.
2. AKESSON, N. B. A statement concerning drift problems in the application of 2,4–D by aircraft. Down Earth 10(4):16–18. Spring 1955.
3. BAGLIUK, A. D. Equipment for spraying sugar beet fields with poisonous chemicals. (In Russian) Sakh. Promysh. 29(2):39–41. 1955.
4. BALS, E. J., and ROSE, G. J. Low volume spray proves its worth. Grower (London) 43:1367, 1369. June 4, 1955.
5. BAUMGARTNER, L. L. A case history of a misapplication of CMU for aquatic weed control. Noeast. Weed Control Conf. Proc. 9:559–562. 1955.
6. BENMOSCHE, J. Portable sprayers. Pest Control 23(7):24. July 1955.
7. BEREZOVSKII, M. IA. In regard to agronomical requirements from machinery for chemical weeding of cereals. (In Russian) Vsesoiuzn. Akad. Sel'skokhoz. Nauk im. V. I. Lenina. Sekts. Zashch. Rast. Trudy 21:185–193. 1953.
8. BLACK, D. T., DITMAN, L. P., and BURKHARDT, G. J. A high-clearance self-propelled sprayer for sweet corn. U.S.D.A.C. 946, 13 p. Nov. 1954.
9. BORDEN, A. D. Operation of air-blower sprayers. West. Fruit Grower 9(2):21–22. Feb. 1955.
10. BROWN, D. South sees increased usage of L.P. gas for cotton cultivation. Butane-Propane News 17(6):56, 58, 60. June 1955.
11. BRUNNER, B. Burning for control of weeds with L. P. gas weed burning equipment. Calif. Weed Conf. Proc. 7:33. 1955.
12. CARPENTER, K., and WALKER, R. An apparatus for the laboratory evaluation of herbicides. Cong. Internatl. de Phytopharm. (Compt. Rend.) 3(2):12–17. 1952, pub. 1954.
13. CARR, J. P., and PATTERSON, J. M. Application of chemicals with air sprayers. J. Agr. & Food Chem. 2:1102–1104. Oct. 27, 1954.
14. CHAMBIONNAT, A. Sequestrants et phytohormones. 2. Terre Marocaine 29:223–230. Ref. June 1955.
15. COSOLO, S. A new system of application by spray pumps. (In Italian) Macch. & Motori Agr. 13(2):71–75. Feb. 1955.
16. COURSHEE, R. J. The development of spraying machinery. 1. World Crops 6:439–441. Nov. 1954.
17. ———. The development of spraying machinery. 2. World Crops 6:485–487. Dec. 1954.
18. ———. Testing of spraying nozzles in the field. World Crops 7:80. Feb. 1955.
19. CREASY, L. E., and WILSON, C. E. Equipment factors affecting the application of wettable powder formulations of substituted urea herbicides. Noeast. Weed Control Conf. Proc. 9:41–51. 1955.
20. CROSS, M. W. Tractor-mounted sprayers for pasture weed control. New Zeal. Farmer 76(5):15–16. May 5, 1955.
21. DANIELSON, L. L. Experimental use of herbicides impregnated on clay granules for control of weeds in certain vegetable crops. Noeast. Weed Control Conf. Proc. 8:119–126. 1954.
22. DEKKER. Power knapsack mist sprayers. (In Dutch) Nederland. Fruittelers Organ. Berbl. 11:36–37. Mar. 1955.
23. DELVI, M. H. Spraying and dusting equipment and technique. Mysore. Dept. Agr. Mysore Agr. Cal. 1954:144–146.

24. DICKISON, W. Hydraulic power sprayers. Pest Control 23(7):24,26. July 1955.
25. DIETSCH, W. Mechanical considerations for control of woody plants. No. Cent. Weed Control Conf. Proc. 11:104–105. 1954.
26. DURHAM, O. C. The contribution of aerobiology to weed control. Noeast. Weed Control Conf. Proc. 9:481–489. Ref. 1955.
27. ELLENWOOD, C. W., and YODER, J. T. Two methods of tree removal. Ohio Farm & Home Res. 40:52–53. May/June 1955.
28. ENNIS, W. B. Influence of volume of spray upon the efficiency of DNBP and CIPC as pre-emergence herbicides. So. Weed Conf. Proc. 8:309–315. 1955.
29. FAIRBANKS, G. E. Plans for building and operating a weed control sprayer. Agr. Res. Assoc. Rpt. 5(2):12–23. June 1955.
30. FEIS, N. Construction of knapsack mist-blowers. (In Dutch) Netherlands Dir. van de Tuinbouw. Meded. 18:193–196. Mar. 1955.
31. ———. Further development of mist-sprayers. (In Dutch) Netherlands Dir. van de Tuinbouw. Meded. 17:674–681. Aug./Sept. 1954.
32. FISHER, J. W. Solution hose. Pest Control 23(7):28. July 1955.
33. FUTRAL, J. G. The design of spray equipment for farm use. Ga. Expt. Sta. Res. News 5:5. Jan. 1955.
34. GEEL, J. D. W. VAN. Rural demonstration at Twello. (In Dutch) Fruitteelt 45:569–571. June 18, 1955.
35. GRANCINI, P. Guida ai trattamenti diserbanti (Guide to spraying for weed control). Inform. Agr. (Verona) 11:81, 83–98. Feb. 20, 1955.
36. GRANO, C. X. Girdle your weed trees in the spring. Forest Farmer 14(4): 6, 16. Jan. 1955.
37. HARVEY, W. A., JONES, L. G., and STEVENSON, E. E. Shielded spraying in row crops for weed control in California. Agron. Abs. 47:77. 1955.
38. HENDRIX, F. F. A simple, inexpensive pre-emergence sprayer. So. Weed Conf. Proc. 8:411–412. 1955.
39. HOLEKAMP, E. R. Cotton's burning question; flame cultivation, its costs and advantages, discussed by U. of A. agricultural engineer. Ariz. Farmer-Ranchman 34(9):6–7. Apr. 30, 1955.
40. ———. Flaming and mechanical methods for weed control. Cotton Gin & Oil Mill Press 56(7):24, 48. Mar. 26, 1955.
41. HOUGHTON, R. Aerial spraying and dusting. Brit. Columbia Agron. Assoc. Conf. Rpt. 1955:68–70.
42. INGERSON, H. G. There's profit in knowing and selling power sprayers. Impl. & Tractor 70(11):44–45,122–234. May 21, 1955.
43. JACOBSSON, A. Modern sprayers require strong parts. (In Swedish) Lantmannen 39:491–493. May 28, 1955.
44. KAL'NIN, M.M., and MAGONE, IA. IA. Scientific conference on methods of application of growth substances, minor elements, and herbicides. (In Russian) Latv. PSR Zinatnu Akad. Vest. 7:153–156. 1954.
45. KEEPERS, W. F. Tank type sprayers. Pest Control 23(7):26. July 1955.
46. ———, and LEWIS, D. P. Spraying equipment market. I–II. Farm Equip. Retailing 19(5):22–28,70. May 1955.
47. KELLY, J., and FALKENSTEIN, W. Effect of pesticides on application equipment. Agr. Chem. 9(11):39–41, 124–125, 127. Nov. 1954.
48. KEMP, H. Faster, better work by air blast concentrate sprayer. Grower (Adelaide) 9(3):35–36. Sept. 1954.
49. KOGH DE BROTOS, L. Aplicacion de herbicidas. Urguay. Min. de Ganad. y. Agr. B. Inform. 11(554):9, 11. Mar. 24, 1955.
50. KOOPMANS, M. J. A laboratory method for the estimation of phytotoxic action. Cong. Internatl. de Phytopharm. (Compt. Rend.) 3(2):31–34. 1952, pub. 1954.
51. KOVACEVIC, J., KVEDER, S., MUNK, R., and VOLARIC, B. 2,4–dichlorophenoxyessigsaure (2,4–D) als selektives herbicid. (In Serbo-Croatian.) Biljna Proizvodnja 7:44–48. 1954.
52. LANDRETH, J. Pressure regulation of knapsack sprayers. Ceylon. Tea Res. Inst. Tea Q. 25:62. Sept. 1954.
53. LANE, F. W. J. Choosing a sprayer. Farm Mech. 7:92–96. Mar. 1955.

54. LARSON, R. E. Mechanical considerations. No. Cent. Weed Control Conf. Res. Rpt. 11:150–157. 1954.
55. LEINWEBER, C. L., and MCCULLY, W. G. An inexpensive controlled—environment chamber for herbicide research. Weeds 3:143–145. Apr. 1954.
56. LILJEDAHL, L. A., and STRAIT, J. Some laboratory and field tests of broadcast nozzle sprayers. No. Cent. Weed Control Conf. Proc. 11:65–70. 1954.
57. LIPSHITZ, N. Cleansing sprayers from remnants of hormone grass-killers. (In Hebrew) Hassadeh 35:825. July 1955.
58. MALETIC, J. T. Preventive weed control—methods and equipment. Amer. Soc. Sugar Beet Technol. Proc. 8(1):291–295. 1954.
59. MCCULLY, W. G. Some factors influencing woody plant control obtained by the soil injection method. So. Weed Conf. Proc. 8:233–236. 1955.
60. MCLANE, S. R., DEAN, E. W., and MINARIK, C. E. Precision sprayer for small plots. Weeds 3:75–79. Jan. 1954.
61. MCWHORTER, C. G., WOOTEN, O. B., and HOLSTUN, J. T. A study of seedbed smoothing devices for pre-emergence weed control in cotton. So. Weed Conf. Proc. 8:42–56. 1955.
62. NASH, R. L., WALLACE, K. E., and DERSCHEID, L. A. Comparing ground and air applications of 2,4–D on wheat. No. Cent. Weed Control Conf. Proc. 11:54–56. 1954.
63. NEPP, C. Sprayers with motor power. (In Italian) Agr. Romagn. 50(2):4. Jan. 20, 1955.
64. ONOGI, M., and KOBAYASI, H. A study of the fire weeder. (In Japanese) Gifu U. Facul. Agr. Res. B. 3:201–217. Mar. 1954.
65. PAVLOVSKII, I. V. OKP–15 combined sprayer. (In Russian) Sel'khozmashina 5:13–14. May 1955.
66. PETERSON, V. M. Set of machines for the preparation for plowing of virgin soils and wastelands which are overgrown with scrub and brushwood. (In Russian) Sel'khozmashina 10:8–9. Oct. 1954.
67. PFEIFFER, R., BRUNSKILL, R. T., and HARTLEY, G. S. A variable dosage sprayer for agricultural experiments. Nature (London) 176:472–473. Sept. 3, 1955.
68. PHILIPSE, W. The knapsack mist sprayer. (In Dutch) Groenten en Fruit 10:168–169. Aug. 19, 1954.
69. POIGNANT, P. Deux methodes qualitatives rapides d'estimation de la phytotoxicite comparee des herbicides de contact. Cong. Internatl. de Phytopharm. (Compt. Rend.) 3(2):66–74. 1952, pub. 1954.
70. PULIGA, E. Q. Utility and dissemination of sprayers. (In Italian) Humus 10(12):23–24. Dec. 1954.
71. RAY, H. Spray your brush to death. Ark. Farmer 57(4):20–21. Apr. 1955.
72. RIPPER, W. E. Application methods for crop protection chemicals. Ann. Appl. Biol. 42:288–324. Ref. Feb. 1955.
73. ROE, E. I. Possibilities of aerial spraying in forest management in the Lake States. No. Cent. Weed Control Conf. Proc. 11:109–112. 1954.
74. ROTH, G. A. Factors affecting spray distribution from a light high-wing airplane. Tex. Agr. Aviation Conf. Papers 3:F1 –F–16. 1954.
75. RUSSCHEN, J. Testing of various sprayers at Wolversum. (In Dutch) Netherlands Dir. van de Landb. Verslag van het Landbk. Onderz. in Noordelijk-Groningen 1954:84–89.
76. RYAN, F. E. Park land clearing. West. Austral. Dept. Agr. J. (ser. 3) 3:651–652. Nov./Dec. 1954.
77. SHIMODA, M. Research on the clearing of fern site. 1. On the extermination of fern by means of flame projector. (In Japanese) Rin-Go-Shiken-Hokoku 79:119–124. Mar. 1955.
78. SIJPKENS, J. P. Mechanical reclamation in Australia. (In Dutch) Landbk. Tijdschr. 66:817–835. Dec. 1954.
79. SIMPSON, G. W. A century of sprays and sprayers. New Eng. Homestead 128 (15):14–15. Aug. 13, 1955.
80. SOUTH DAKOTA STATE COLLEGE OF AGRICULTURE AND MECHANIC ARTS EXTENSION SERV. Checking weed sprayers. S. Dak. State Col. Agr. Ext. L. 156, 2 p. May 1954.

81. TRUMAN, L. C. Weed and lawn insect control. Pest Control 23(7):18. July 1955.
82. VIJFWINKEL, L. The oldest motor sprayer. (In Dutch) Fruitteelt 45:7. Jan. 1, 1955.
83. WATKINS, I., FIELD RESEARCH DIV. A manual of weed control. New Plymouth, N. Z., 1954.
84. WESTCOTT, C. Note on materials and equipment. Plants & Gard. (n.s.) 11:95–96. Spring 1955.
85. YEO, R. R. Modern weed control applicators. N. Mex. Agr. Expt. Sta. B. 391, 24 p. Jan. 1955.

IX. LEGAL ASPECTS

1. BALL, W. S. Regulatory aspects in weed control. Weeds 3:38–44. Jan. 1954.
2. BJERKEN, S. The Minnesota weed laws. No. Cent. Weed Control Conf. Proc. 11:25. 1954.
3. CHAPMAN, C., and EDWARDS, T. Herbicide law enforcement program of the Texas Department of Agriculture. Tex. Agr. Aviation Conf. Papers 8:G1–G7. 1955.
4. DREESSEN, J. The effect of legislation on herbicide research and use. Agron. Abs. 47:77. 1955.
5. GILBERT, C. J. Regulatory Committee report Federal legislation concerned with federally owned or controlled lands. No. Cent. Weed Control Conf. Proc. 11:135. 1954.
6. HITCHNER, L. S. The effect of legislation and regulation on herbicide research and use. So. Weed Conf. Proc. 8:14–19. 1955.
7. LEMMON, A. B. Injurious herbicide regulations. Calif. Weed Conf. Proc. 7:59–60. 1955.
8. NOONE, J. A. Problems in registration of a new herbicide. Noeast. Weed Control Conf. Proc. 9:1–6. 1955.
9. WINTON, C. Weed laws are important. No. Cent. Weed Control Conf. Proc. 11:28–29. 1954.
10. WOESTEMEYER, V. W. Weed laws are important. No. Cent. Weed Control Conf. Proc. 11:28. 1954.

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